THE FRANKLIN INSTITUTE LABORATORIES

for

RESEARCH *and* DEVELOPMENT

20th Street and Benjamin Franklin Parkway
PHILADELPHIA 3 PA.

R & D IN CONNECTION WITH THE DESIGN OF PROGECTION MAGNIFIER FOR USE BY THE SEMI-BLIND
by Herbert Jehle & Wallace Frank

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Optical aids

RESEARCH REPORT NUMBER 319

RESEARCH AND DEVELOPMENT IN CONNECTION WITH THE DESIGN OF PROJECTION MAGNIFIER FOR USE BY THE SEMI-BLIND

By:

Herbert Jehle
Wallace Frank

Reviewed by:

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A final report on the work done on

CONTRACT VAm-21223,
SUBCONTRACT 21

C.S.D. SERIAL #47-4

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Respectfully submitted,

Nicol H. Smith

Nicol H. Smith, Director
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Date: March 1, 1947

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A. A. Bombe
Technical Aide
Committee on Sensory Devices

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ABSTRACT

Ideal specifications have been written for the components of a projection magnifier intended to be used as a visual aid by the semi-blind. Three different models have been designed and constructed and are described in detail herein. Lines of possible future development have been outlined.

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1. INTRODUCTION

1.1 General Purpose

The purposes of this report are to give an analysis of the factors relevant to the design of projection magnifiers intended to serve as visual aids for the semi-blind, and to describe the three models which have been constructed.

1.2 Scope

This contract calls for research and development in connection with the design, the construction and the testing of two projection units with a magnification of approximately twenty-five diameters and of two with a magnification of approximately six diameters.

1.3 Authorization

The work reported herein is in partial fulfillment of Contract VAm-21223, Subcontract 21 with the Veterans Administration.

1.4 Historical Outline

In 1943, discussion by one of the authors of this report with interested persons and organizations revealed the need for an improved visual aid for the partially blind. It was felt that this need could be satisfied by a device in which a magnified image of the printed material would be projected upon a screen before the observer. Hence a crude device was built which could be operated only in a darkened room and, although successful, was found to cause rapid fatigue, due to erratic movement of the image, in an observer unable to read normal print unaided.

An improved model was constructed, in 1945, by the aid of a Milton

Grant from Harvard University, and tested with reasonable success by partially blind persons with a wide range of visual acuity.

In 1946, the Catholic Guild for the Blind, in Boston, granted funds to spur the development of projection magnifiers and to secure the delivery of one pilot model which could be tested thoroughly under normal operating conditions. During the past year a contract was consummated between the Veterans Administration, acting through the Committee on Sensory devices of the National Research Council, and the Franklin Institute, which provided for intensive development and the delivery of four units.

2. BASIC PROBLEMS - FEATURES OF THE IDEAL SOLUTION

2.1 Opthalmological Requirements

The report of V. J. Ellerbrock,* defines the numerical range of subnormal vision so as to include all those individuals with a visual acuity, after correction, of from 20/70 to 20/200 Snellen inclusive. However, persons with seriously impaired vision may be capable of reading magnified print, even with poor illumination, provided the contrast is sharp and the print is held close to the eyes.

2.1.1 Present Instrumentation

The basic means for enabling the partially blind to read are: 1) a headborne simple lens, 2) a large fixed lens with a wide field, 3) telescopic spectacles, 4) a projection magnifier. With these devices either prolonged use results in fatigue of the eyes in correcting for unperfect focus, and of the head and hands in manipulating the printed material, or high magnification is not attainable. However, a projection magnifier permits a relatively high magnification without excessive strain upon the user; requires a not unduly complicated illumination system; and is neither too large nor too costly for wide use.

The primary elements of a projection magnifier are: a source of illumination, a lens and a screen which may be arranged in one of several possible ways, as shown in Figures 2-1, 2-2, and 2-3. Other components must be added to attain a more refined and workable unit, but mirrors, elaborate scanning mechanisms, etc., do not render the primary elements dispensable or change their functions. The verb "scan", as used in this report, means to

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* Report on Survey of Optical Aids for Subnormal Vision, Dartmouth Eye Institute, Hanover, N. H., Nov. 15, 1945.

change the field projected upon the screen in order that an area too large to be projected at one time, may be completely scrutinized.

2.2 Projection Magnifiers

At a small magnification a full line of a book may be projected upon the screen but at a large magnification this is impracticable. A projection magnifier should be designed so that the learning period is a minimum and time is not lost in accomodation whenever the device is employed.

The ideal specifications for each of the necessary components of a projection magnifier are discussed here without regard to their mutual compatibility. The optical system must permit the user to read very close to the screen without obstructing the light with his head. A large screen at a distance requires either a darkened room or a large enclosed apparatus and both a higher magnification and a much more intense illumination. For these reasons, projection from behind is the most desirable arrangement, and this requires the use of a translucent screen.

2.3 Screen

There remains the problem of locating and orienting such a translucent screen. A satisfactory arrangement is an almost vertical screen so placed that the reader can scan it at close quarters while comfortably seated. Those who have to read at close quarters would, doubtless, prefer a screen of small area, since head and body movement are then minimized. On the other hand, a small screen, at low magnification, may not accomodate an entire line, and, at high magnification, requires excessive movement of the scanning device and too great skill in locating the desired place on the page. It has been found that a screen of thirty inches width most nearly satisfies the conditions for optimum utility.

A satisfactory translucent screen should transmit a large percent of the incident light and scatter it evenly and uniformly. The screen material should change neither its physical dimensions nor its optical properties with age or with changing atmospheric conditions. It must be permanently plane, noninflammable, rugged, and should not shatter or leave dangerous cutting edges in the event of accidental breakage. Finger marks caused by tracing must be easily removable.

2.4 Magnification

No designation of one particular magnification as the optimum can readily be made. It is possible, however, to choose a particular magnification, within the range required, on the basis of reasonable assumptions concerning the use to which the magnifier is to be put. If it is assumed that a book with wide columns (4.3 inches) is to be projected upon a 30-inch screen, then a magnification of about six times is indicated in order that a complete line may be projected upon the screen. A reader with vision only slightly impaired may keep his head sufficiently far from the screen to read an entire line without undue head and body movement. A screen-to-eye distance of about one foot will not require excessive change of position and the book need only be moved vertically a few lines at a time. At a magnification of the order of twenty-five times, a pica letter will appear about 2 inches in height. Though a magnification of twenty-five times may be just below the threshold of enlargement necessary for some persons, in all probability it is beyond the point of diminishing returns to secure higher magnification, since the letters then become fuzzy and excessive movement of the scanning device is necessary. At higher magnifications the rate of reading is low and the intensity of illumination in order to maintain reasonable brightness upon the screen is unduly

high. Without such illumination the brightness of the image upon the screen is too low.

No one magnification can be expected to satisfy all persons, nor will one magnification necessarily suit any one person under all circumstances, but the introduction of additional complexity and expense in order to satisfy the varying requirements of one person is not justifiable. For public use, as in libraries, it may be advantageous to have a projection magnifier with more than one possible magnification ratio. If an apparatus with more than one magnification ratio can be made to operate without detriment to performance at any one ratio, a more adaptable and useful product will result. The shift from one magnification to another should be simple enough so that maintenance and adjustment may be carried out by persons unfamiliar with the apparatus.

2.5 Mirrors and Optical Path

Unless the optical path includes an even number of mirrors, inversion of the image will result. Without the use of mirrors the printed material must be located uncomfortably far from the screen. If mirrors are to be used, they must be front-surface reflecting so as to avoid the formation of multiple images which cause blurring of the final image. Inversion of the image will occur unless mirrors are introduced into the optical path in pairs. The addition of each pair increases the probability of a defective image due to inaccuracies of surface and accumulation of dust. Mirrors are heavy, expensive and fragile. Their reflecting quality is difficult to maintain. Hence the number of mirrors used should be kept as small as possible.

The length of the optical path is a function of the focal length of the lens and of the magnification desired. The shorter the path, the more

compact is the apparatus. The minimum path is determined by the back focus of the lens. By "back focus" is meant the distance between the object plane and that element of the lens which is nearest to the object plane. This distance must be sufficient to permit the adequate illumination of the entire object plane by the light source. If the back focus is too short, the light will be incident upon the reading material at almost grazing incidence, which makes satisfactory illumination difficult, and reduces the maximum efficiency of illumination.

With all other conditions fixed a faster lens gives a brighter image, since the illumination on the screen is proportional to (speed of lens/ magnification)^2. If the lens is to be reasonably small and inexpensive, it must also have a short focus, which permits a short optical path; but a more satisfactory arrangement of the illuminating system may be obtained with a lens of long focus, although that requires the use of a mirror before the lens because of the longer optical path.

Many who suffer from loss of visual acuity do not at the same time suffer from loss of function. Such persons may read provided the enlargement is sufficiently great, but do not require high illumination. For those who have anomalies of the eyes resulting in loss of resolving power, a loss of function is also evident, and it is important that these persons be provided not only with sufficient magnification but with a sufficiently high degree of contrast. Extensive experimentation will be necessary to determine the threshold of contrast necessary for a predetermined proportion of the group having subnormal vision. From this point of view, it is advantageous to have projection magnifiers which represent several degrees of contrast in order that some basis of comparison may be provided.

2.6 Methods of Scanning

As only a fraction of a sheet may be projected upon the screen at any one time, some sort of scanning device must be employed. It is possible to move the lens system so as to change the optical path in space as the reader progresses over a page, or the book may be moved in a fixed area which is constantly projected upon the screen, or the two methods may be combined.

2.6.1 Moving Lens System

A projection magnifier with a moving lens system permits freedom of location and remote control of the material to be read, but the difficulties encountered in the design of such a system are both optical and mechanical. A satisfactory design must include a mechanism for maintaining constant magnification without distortion and such a mechanism may be complicated, expensive, sensitive to careless handling and in need of frequent calibration.

2.6.2 Moving Book

If the book is to be moved, instead of the lens system, the only requirements are that the scanned page remain in the object plane of the lens and that movement be smooth and easily controlled either directly or by knobs or levers which may be located at a point convenient for the reader. A knob control would probably necessitate a fine adjustment to be used when reading at high magnifications and a coarse adjustment to be used for the large movements necessary for location on the page. Either knob or lever control would require the user to be educated in their operation, and the period of education should be a minimum. Thus simplicity is lost by the use of indirect control.

Direct movement of the book possesses the advantage that the direction of motion may be almost instinctive and only a feeling for the magnitude of the movement must be acquired. Thus simplicity of operation can be achieved

by the use of direct control.

2.7 Location of Book

The most desirable location of the book, requiring the least re-education for ready use, is probably that used by persons with normal sight. A horizontal location, face up, is approximately the most desired orientation. Either a frame or a transparent plate may then be used to hold the page flat. From the point of view of ease in manipulation there is little choice whether the book is held face up or face down, but in either case it must remain flat while its carriage moves smoothly, without slip, in any horizontal direction.

The device which holds the book flat in its working location should also prevent light leakage around the book, since a gleam of light can temporarily blind the reader. This device should be comfortable to use, odorless, easy to remove and useful as a screen to protect the hands from the heat associated with the illuminating system.

2.8 Illumination

Illumination must be adequate and uniform over the entire field. There should be no internal reflection in the lens system. The illuminating system should be simple involving rugged permanent elements and easily replaced expendable ones. As much of the supplied light as possible should be utilized both by the proper direction of the rays and by the use of a reflector system to reduce stray light losses. The illuminating system should be designed for a particular application, which may mean that a system adequate for illuminating the area to be scanned at one magnification will be unsatisfactory when employed with a different area associated with another magnification. If the projection magnifier is to be capable of operation at more than one

magnification, the illumination at all magnifications must be adequate, although maximum efficiency will not be attained for all magnifications.

2.9 Type of Chair

The amount of special equipment needed should be kept as low as possible. Therefore, the projection magnifier should be so designed that either ordinary or special chairs may be employed in connection with its use.

2.10 Safety

Special consideration must be given to the safety of any device to be used by handicapped persons with a view to their particular limitations. The projection magnifier should be as fireproof as possible, and careful attention should be given to those elements which, if permitted to catch fire, would be likely to cause panic. Since some sort of light-tight enclosure is required, every effort should be made to see that no situation may arise in which the user of the magnifier feels trapped and unable to escape from the hood or roof which surrounds him. Flammable materials should be kept away from heat sources and the possibility of electric shock should be reduced to a minimum. The device should be made foolproof throughout and all designs should be based upon the assumption that it is the unexpected that will happen. Adequate ventilation, especially in warm weather, should also be provided for the health and comfort of the user.

2.11 Adaptibility

Operation of the magnifier should be possible without the use of special facilities, such as a subdued light or a darkened room. All electrical components should be capable of functioning when supplied with 110-volt alternating or direct current and the operator should be required to plug in but

one line. If several magnification ratios with the same unit are possible, the process of interchanging lenses should be simple. Persons operating the projection magnifier cannot be presumed to be familiar with even the most elementary principles of electricity or of mechanics. It is desirable that the device should occupy minimum space, have minimum weight and be portable.

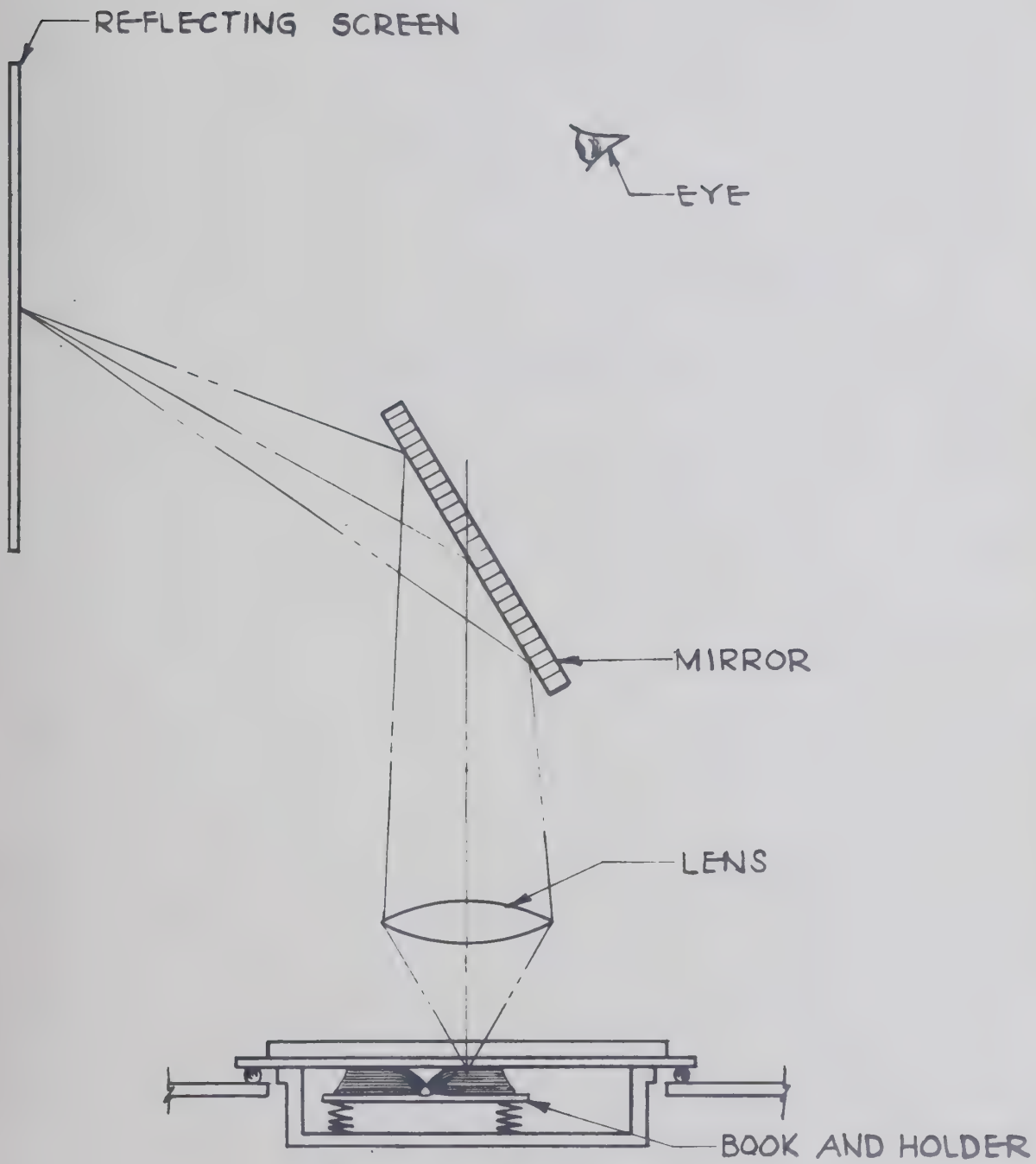


FIG. 2-1 REFLECTING SCREEN PROJECTION MAGNIFIER

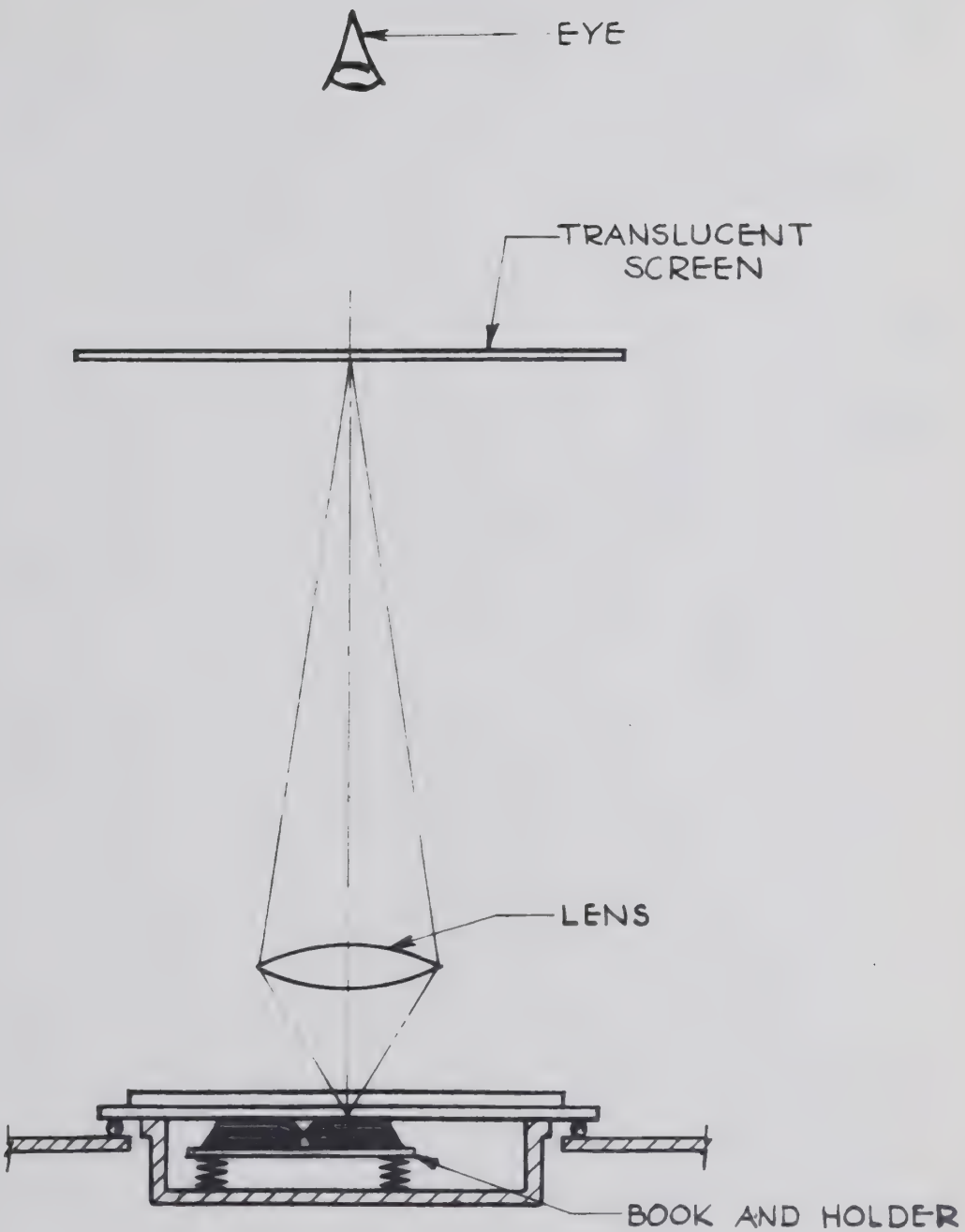


FIG. 2-2 HORIZONTAL SCREEN PROJECTION MAGNIFIER WITHOUT MIRRORS

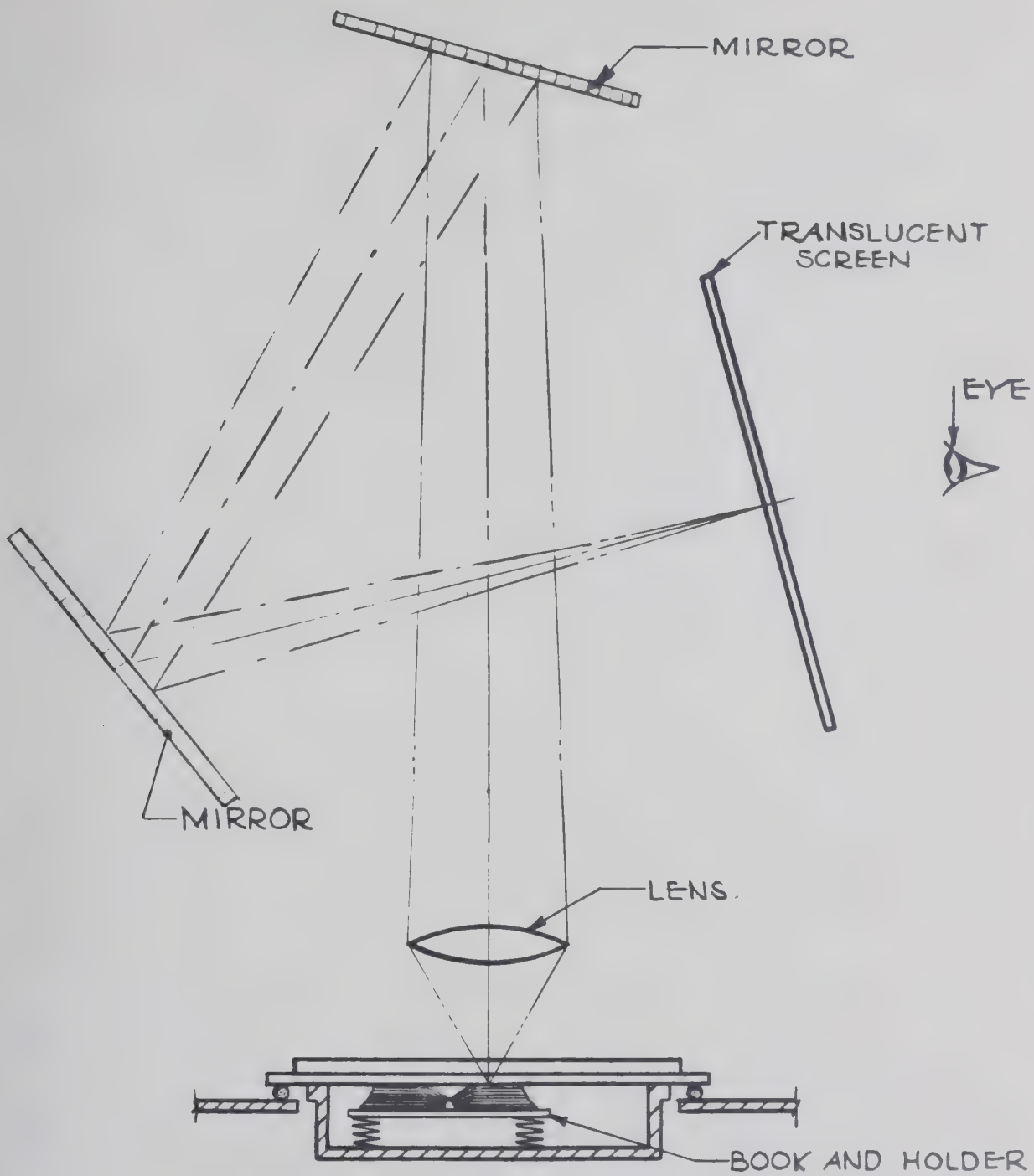


FIG. 2-3 VERTICAL SCREEN PROJECTION MAGNIFIER USING OVERHEAD MIRROR

3. DESIGNS OF THE PROJECTION MAGNIFIER

3.1 Three Models

The three designs of the projection magnifier which have been constructed may be described as follows: 1) the horizontal screen, rigid frame model; 2) the vertical screen, rigid frame model; 3) the collapsible model. Each model represents a stage in the development of the final model #3 and each represents a somewhat different concept of the optimum design. Fundamental changes have occasionally been made which are not necessarily desirable from the over-all standpoint. For instance, it may be more desirable to have an inexpensive and simple illuminating system than one which is optically superior but mechanically more complicated (See Section 3.2.3).

3.2 Horizontal Screen, Rigid Frame Unit

Several views of this unit may be seen in Figures 3-1 to 3-5. They should be studied to gain some comprehension of the over-all design in order that the details may be better appreciated as they are separately presented.

3.2.1 The Screen

The screen of this unit is nearly horizontal and placed directly in front of the user, hence the act of reading is similar to that of reading a book on a table. If the reader's eye-to-screen distance is great enough, no undue strain of eye, neck, or back will accompany its use. If the reader's eye-to-screen distance is comparatively short, it will be necessary for him to lean over the apparatus in a position which will not be very comfortable

for a long period. The size of the screen is 12 x 19-1/2 inches which, at the magnification to be used, permits the scanning of an area 2-1/2 in. x 4-1/2 in. at one time. The screen is of rubberized cloth with good light diffusing properties and low absorption. It satisfies the requirements of washability, dimensional stability and noninflammability as well as being shatter proof.

3.2.2 Magnification

The one lens supplied with the unit gives a magnification of about five times which satisfies the original specifications for a projection magnifier of low power. With the existing light path and a slight change of lens mount a magnification up to twelve times might be achieved by a judicious choice of lens. The lens, of high quality, is designated commercially as a Bush Glauker-Anastigmat, f/3.1, f = 18 cm. This lens should not necessarily be used for a large number of similar projection magnifiers. In this case, the choice was influenced by the immediate availability of this particular lens.

3.2.3 Optical Path

The horizontal screen, rigid-frame projection magnifier has two mirrors in the optical path, both between the lens and the screen. As may be seen from Figure 3-3, the light travels from the incandescent lamps to the surface scanned. It then passes down through the lens to the first mirror, to a second mirror, and then up to the screen, a total distance of about 45 inches. This distance will be the limiting factor if an attempt is made to secure higher magnification. Since the magnification is always dependent upon the ratio of the image distance to the object distance, and

since the latter is limited by illumination considerations, magnifications greater than twelve times are impracticable with this 45-inch light path. Adjustment is provided for the smaller mirror so that should any misalignment occur as a result of rough handling, the operator may make corrections readily. The dimensions of the small mirror are 4-3/4 in. x 4-3/4 in., and the large mirror is trapezoidal, having an altitude of 23-1/2 in. and bases of 12 in. and 18 in., respectively. The mirror supports are of structural aluminum shaped for light weight and high strength.

3.2.4 Location of Book

As may be seen from Figure 3-3, the book is to the right of, and on the same level as, the screen. The user will normally sit directly in front of the screen and control book movement with his right hand. The level of the book is such that the hand and arm of the reader rest at a convenient height.

3.2.5 Method of Scanning

The method of scanning is the same in all three models of the projection magnifier (See Fig. 3-4). Details will be described in connection with the other units (Section 3.3.5).

3.2.6 Illumination

The source of illumination is a bank of five 40-watt incandescent lamps without reflector. These lamps have a long life and may be replaced with ease (Figs. 3-2 and 3-3). The intensity of such a light source is low, the efficiency of utilization poor, and the degree of contrast with the horizontal screen unit is less than that with the other units, but the contrast

should be sufficient to satisfy many of the semi-blind. With only five lamps the evenness of illumination is not as good as with a system having a better distribution of light but no distinct shadows will be found in the images formed by this magnifier.

3.2.7 Table

The height of the table of this unit is 34-1/2 in. which makes an ordinary straight-back chair convenient for use in its operation.

3.2.8 Hood and Housing

The horizontal screen, rigid frame projection magnifier is equipped with leg extensions so that for shipment the minimum space will be occupied. The hoods are sufficiently light tight to permit use of the device in subdued light and a hood of heavier material might make operation possible in broad daylight. The hoods rest upon wire frames which may be removed for shipment or storage. The lamps and the mirrors are both enclosed in metal dust-free housings in which doors have been provided for easy access (See Figs. 3-2 and 3-3). The large mirror is reached by folding back the screen.

3.2.9 Adaptability

The only electrical components of this projection magnifier are the standard 40-watt lamps which operate at 110 volts. There is a single toggle switch on the side of the box which encloses the light source. No noise accompanies use and the enclosed scanning device causes no nuisance. The magnifier may be readily and safely shipped since projecting parts are removable and essential elements are rigidly fixed in their operating positions protected from accidental injury. The unit is light in weight, extremely rugged,

and contains no expensive elements, except the lens, for which one of lesser quality might satisfactorily be substituted in case of reproduction at a relatively low cost. The mirrors, which are silvered on the back, require no special care in cleaning.

3.3 Cabinet Model

An assembly drawing of this rigid-frame, vertical-screen projection magnifier known as Type A, is shown in Figure 3-8 and should be examined before consideration is given to the many details (See also Figures 3-6 and 3-7).

3.3.1 Screen

The screen, 26-1/2 in. x 15-1/2 in., is slightly inclined to the vertical plane in the normal operating position, and located directly in front of the reader's eyes. The screen material is Plexiglass Translucent 122-50 white, 0.060 in. thick, made by the Rohm and Haas Company of Philadelphia. It has been selected because of its high transmission coefficient, good diffusion, noninflammability, good mechanical strength, dimensional stability, and washability. It may be changed by removing a wooden frame held in place by four screws. An alternate screen material is Vinylite, transparent, clear, with matt finish one side, 0.050 in. thick, made by the Bakelite Corporation of Bound Brook, N. J. This screen is more opaque than the plexiglass, since it has a lower coefficient of light transmission, but its slightly different scattering qualities may render it preferable to some persons. The location of the screen makes possible a very small screen-to-eye distance without discomfort to the reader. Those who prefer a greater screen-to-eye distance may use the device without modification, if necessary, by pushing back the chair. Movement of the reading material can be controlled with ease whether the reader is close to the screen or far away.

3.2.3 Magnification

The Type A projection Magnifiers have been designed for use at either of two different magnifications. The sketch of the sectioned lens box shows that two positions are provided for the lens mounts (Fig.3-8), which are to be used one at a time. For high magnifications, a Bausch & Lomb Super Cinephor projection lens, f = 3-3/4 in., is mounted in the upper portion of the tube. A lens, coated with a thin film by the manufacturer, is used because it increases the amount of light transmitted through the lens by reducing internal reflections which seriously effect the desired contrast of the dark letters against the bright background on the screen. Lens mounts have been designed into which the lenses screw and from which they should not be removed by the user. In order to remove a lens already installed, it is necessary only to grasp the lens barrel and lift, being very careful not to touch the glass surfaces. Installation of the lens is the reverse of this process, but it is important that the lens and mount be gently lowered into position and that care be taken to avoid shocks or scratches (See Figs. 3-10 and 3-11). The low power lenses are Bausch & Lomb Balopticon Projection lenses, f = 12 in., 2-5/16 in. diameter, with coated surfaces (See Fig. 3-13).

Some tests have been made with lenses of simpler construction and lower quality to determine whether or not they would satisfy the requirements of this application. In particular a Bausch & Lomb, Catalog No. 81-34-60, 3x, wide-field magnifier was tried with encouraging results. The area of the undistorted field is smaller than the screen, but there is reason to believe that a slightly better magnifying lens might be satisfactory.

3.3.3 Optical Path

The Type A projection magnifier has two mirrors, both between the lens and the screen. The light from the incandescent source is focused by the reflector upon the material to be viewed. From there it passes downward through the lens system to the lower mirror, then diagonally upward and to the back to the large rear mirror, and finally to the screen, a total path of approximately 100 inches. Mirrors with an aluminized front-surface eliminate inaccuracies caused by double reflections and deviations of the reflecting surface from a plane. They must be cleaned with care to avoid damage to the coated surface. The lower mirror and the lens should be dusted frequently with a soft hair brush. Focusing is accomplished by means of the lever located near the bottom of the focusing tube, and when the lens has been focused properly, the lever should be turned so as to lock the tube and the lens in position.

3.3.4 Location of Book

The material to be scanned is located directly in front of the reader and slightly above lap level. The cabinet has been so designed that printed matter up to 17 in. x 20 in. may be inserted at one time, which permits the reading of newspapers and large magazines such as "Life", as well as the examination of ordinary books. The material to be read is placed face down upon a pyrex glass plate and covered with a thick sheet of sponge rubber. The book location has been so selected that the reader may comfortably rest his arms when operating the magnifier.

3.3.5 Method of Scanning

The scanning device consists of a pyrex glass plate which moves with ease over a fixed observation port forward and backward on one track and right

and left on a carriage which travels on another track (See Figs. 3-4 and 3-14). Great care has been taken to reduce friction as much as possible by mounting the carriage on hardened steel rollers which are pinned to the moving frame and roll in specially formed stainless steel tracks (Fig. 3-17). The mat which covers the material to be viewed has several functions: 1) to provide a light seal around the book; 2) to prevent slipping of the book on the plate; 3) to protect the reader's arm from heat from the lamps below; 4) to control the scanning device; 5) to keep the book flat and maintain it in proper orientation while being moved. When a page is to be turned, the mat must be lifted and the book raised and replaced.

3.3.6 Illumination

For the Type A projection magnifiers, automobile head-light lamps were selected because of their high candle power, long life, small size, relatively low cost, availability and constancy of orientation of the filament with respect to the socket. The latter consideration is of the utmost importance for the attainment of high reflector efficiency. Most common automobile lamps operate at 6 volts so that when attached to a 110-volt source they must be either connected in series or used with a transformer. For this application the simpler arrangement appeared to be the former, hence eighteen lamps were connected in series. Preliminary tests of the lamps were made for uniformity of lots and optimum size of lot for greatest efficiency.

Eighteen new lamps from the same lot were permitted to burn continuously until one failed, when it was removed and replaced by a new lamp from the same lot. Each time a lamp failed, it was replaced from the original lot until that lot had been exhausted, after which replacements were made from another lot (mixed replacements). Three lots, A, B, and C, were exhausted in

these experiments. Figure 3-15 shows the average performance of the lamps in the three lots in terms of the variation of the number of replacements required with the number of original lamps remaining. If lamp life were independent of the properties of the other lamps in the series circuit, the graph would be the straight broken line, but lamp resistance changes with age and a new lamp burned in series with old ones has a shorter life than when burned with identical new lamps. Although the lots differed from each other in many respects, the curves were of similar character. The same data are presented as a curve of lamp group performance in Figure 3-16, from which it may be concluded that to attain maximum life from each lamp, not many replacements should be made. With the information acquired from these experiments, as shown in Figure 3-16, it appears that an efficient and practical operating schedule would be to purchase lamps in lots of 20, that is, two boxes 10 each. Eighteen of the lamps should be installed in the projection magnifier and the two extra lamps kept as replacements.

Although higher lamp efficiency, that is, more lumens per watt, might have been achieved with other than incandescent lamp sources, it is advised that the projection magnifier be operated with eighteen No. 1133 automobile lamps, which are single-contact bayonet-base lamps rated at 32 candle-power when operated at 6.2 volts. Various other types of lamps were tested as follows: 1) "circline" fluorescent lamps; 2) discharge lamps containing mercury or sodium vapor; 3) a special aircraft reading lamp with filament at the focus of the reflector; 4) miniature 110-volt lamps; but none were as practicable as the automobile lamps.

Since all of the bulbs cease to function whenever one of the series burns out, a special device is provided for locating the defective bulb.

Connected in parallel with each lamp socket is a neon glow lamp. Upon failure of any of the illuminating lamps, the line voltage is impressed upon the neon lamp in parallel with the failed bulb. This causes that neon bulb alone to glow (Fig. 3-17). When a lamp has failed, therefore, all the illuminating lamps in the light lens box go out and the user merely looks through the hole in the table top to discover which neon lamp is aglow. The defective illuminating lamp is the one on the same radius as the glowing neon lamp, and as soon as a replacement of this lamp has been made the unit is again ready for operation. If two of the illuminating lamps fail at the same time, the neon light opposite each of the defective lamps will glow.

The reflector provided with the vertical screen projection magnifier is a carefully designed spun aluminum reflector. An alternative material is "Alzak" aluminum which has both high reflectivity and resistance to deterioration. Reflectors have also been spun of copper and then chromium-plated, but a copper reflector is relatively heavy.

The source of illumination is surrounded by a light-tight enclosure called the light lens box. This box houses and supports the reflector, the lamp shelf and the lens focusing tube. It protects the reader from stray light and is part of the cooling air chamber.

3.3.7 Chair

The Type A projection magnifier has been designed for use with a regular straight-back chair, although any chair having an 18-in. seat height may be used. The cloth hood is sufficiently large to permit movement of the chair to that position which is most comfortable for the individual using the projection magnifier.

3.3.8 Hood

The hood is made of a light-tight fireproof material attached to the frame by means of "lift-a-dot" fasteners. The top of the hood is supported by a hard aluminum frame, removable for transportation, which is connected to the cabinet. A flap on one side is to be used as a means of entrance and exit. The hem is weighted with a chain so that it falls into place unaided. To enter the cloth housing, the flap is spread apart, and after entrance the flap will, upon release, assume its light-tight position.

3.3.9 Ventilating System

The ventilating system not only cools the user but at the same time removes the heat dissipated by the lamps. The blower is of the centrifugal type powered by a 1/15 h.p. Universal motor. Air, which is withdrawn from the front of the cabinet over the screen, is replaced by leakage through and around the curtain, thus providing a constant stream of fresh cooling air around the reader. The blower discharges through a rubber duct into the light lens box swirling through between the reflector and the outer wall so as to cool the reflector. The hot air is discharged from the light lens box through another duct to an opening which has been provided at the rear of the cabinet (See Fig. 3-18).

3.3.10 Safety Devices

This projection magnifier is so wired that a single switch turns on and off both the blower and the lamps, hence it is unnecessary to remove the plug while the circuit is open. A fuse is installed in the line to minimize the fire hazard as the result of a short circuit. The pyrex plate is not apt to crack as a result of the heat or of any sudden temperature change.

The bulbs are of an easily obtainable type and of rugged construction, designed for use under shock conditions. The device has been made as fire-proof as possible and as rugged and as roomy as other requirements permit. A telltale light mounted on the top of the cabinet glows whenever the switch is on so that, should the reader inadvertently leave the hood with the current on, this warning signal will reduce the possibility of burning out lamps needlessly.

3.3.11 Cabinet Construction

The cabinet consists of a wooden frame to which has been attached internally braced plywood sides and a curved aluminum back. The aluminum and steel table top is mounted upon wooden stiffeners rigidly fixed to the plywood sides. A transverse vertical dividing wall has been installed under and around the light lens box to insure not only that the optical path is kept clear, but also that the optical elements are protected from mechanical injuries. The wooden screen frame is hinged to the cabinet so that it may be swung out of the way when necessary to change lenses or lamps. Details of the construction may be seen in Figure 3-19.

3.4 Vertical Screen, Collapsible Frame Projection Magnifier

The vertical screen, collapsible frame, Type B, projection magnifier is shown in Figures 3-20 and 3-21, from which it may be seen that the optical elements are similar to those installed in the vertical screen, rigid frame projection magnifier, Type A, the differences being in the frame.

3.4.1 Hood

The hood of the Type B projection magnifier extends back further than that of Type A so as to form a larger compartment for the reader. The

top slopes up toward the front to give more headroom. There is a cloth wall to prevent the escape of light through the port to the back of the screen (Fig. 3-20). This cloth has the same function as the diagonal plywood dividing wall in the Type A model.

3.4.2 Ventilating System

Each projection magnifier has been equipped with a centrifugal blower driven by a 110-volt Universal motor. The blower takes air from about the reader, circulates it around the reflector and discharges it from under the hood into the atmosphere (See Fig. 3-22). The same switch controls both blower and lamps. The blower and motor assembly is fastened by means of vibration-absorbing feet to an aluminum stiffener plate which connects the frame members (Fig. 3-22).

3.4.3 Safety Devices

Each collapsible frame projection magnifier has an on-off snap switch, a fuse, and a pyrex book plate. It does not, however, have a telltale light to indicate when the light and blower switch is on. A wiring diagram is shown in Figure 3-23.

3.4.4 Frame Construction

The frame of the collapsible unit is of aluminum alloy 3/4 in. standard-pipe-size (1.05" O.D.). The pins which connect the several members are of cold rolled steel and rest in brass bushings inserted in holes in the aluminum. Permanent connections within the frame structure have been made by welding. For transportation, the entire frame may be collapsed until it occupies a space 70 x 38 x 9 inches after the light lens box, its supporting assembly, mirrors, screen, hood and cloth wall have been removed. When the

unit is to be set up for use it may be opened in a manner analogous to that employed in opening a folding chair. Details of the assembly operation are described in Appendix C of this report.

FIG. 3-1 HORIZONTAL SCREEN, RIGID FRAME PROJECTION MAGNIFIER, READY FOR USE

FIG. 3-2 HORIZONTAL SCREEN, RIGID FRAME PROJECTION MAGNIFIER, WITHOUT HOOD AND WITH ACCESS DOORS OPEN

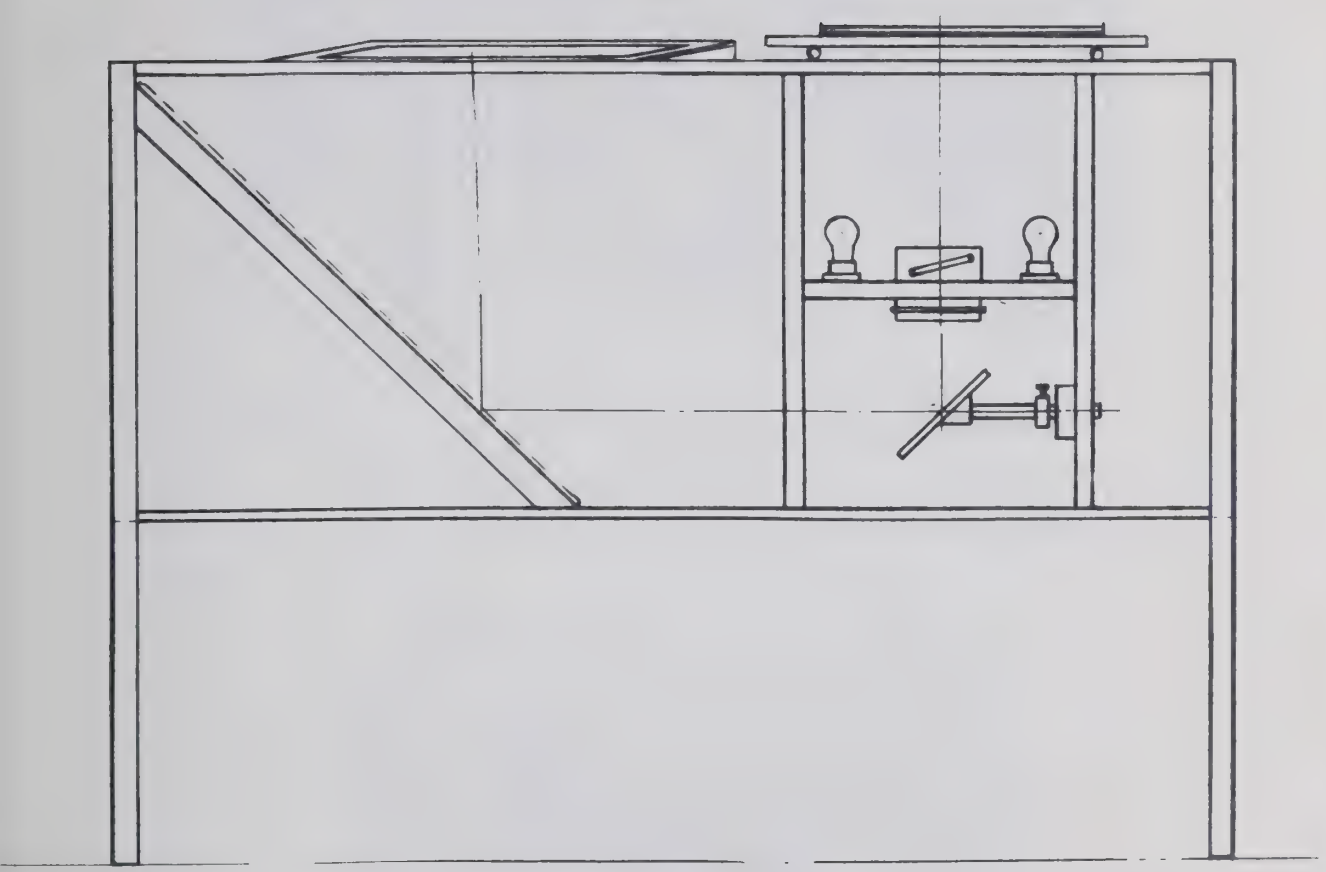


FIG. 3-3 HORIZONTAL SCREEN, RIGID FRAME PROJECTION MAGNIFIER GENERAL ARRANGEMENT

FIG. 3-4 HORIZONTAL SCREEN,
RIGID FRAME PROJECTION MAGNIFIER,
DETAIL OF TABLE TOP

FIG. 3-5 HORIZONTAL SCREEN,
RIGID FRAME PROJECTION MAGNIFIER,
PHANTOM VIEW SHOWING UNIT IN USE

FIG. 3-6 TYPE A PROJECTION MAGNIFIER, HOOD AND CABINET

FIG. 3-7 TYPE A PROJECTION MAGNIFIER, FRONT VIEW WITHOUT HOOD

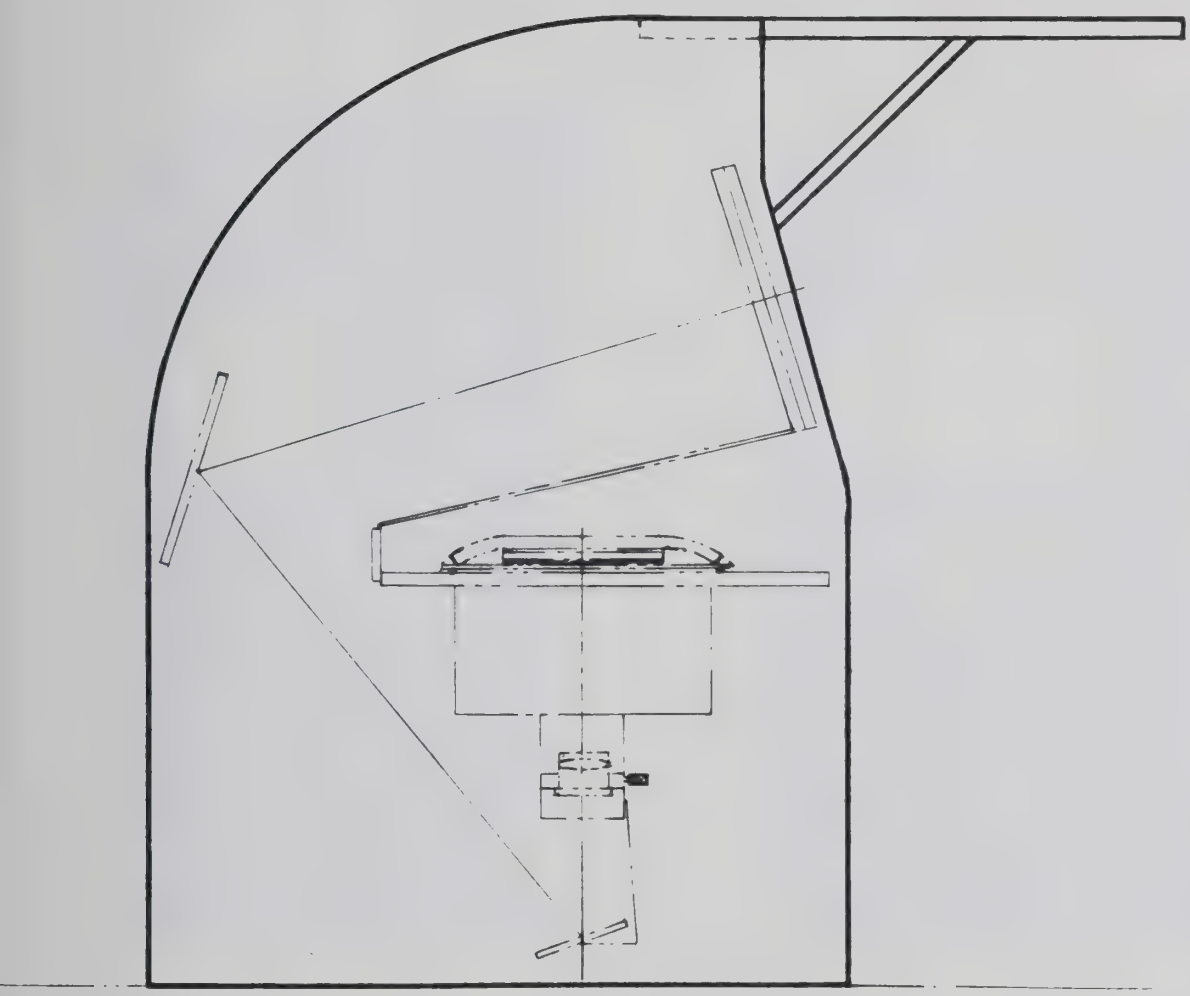
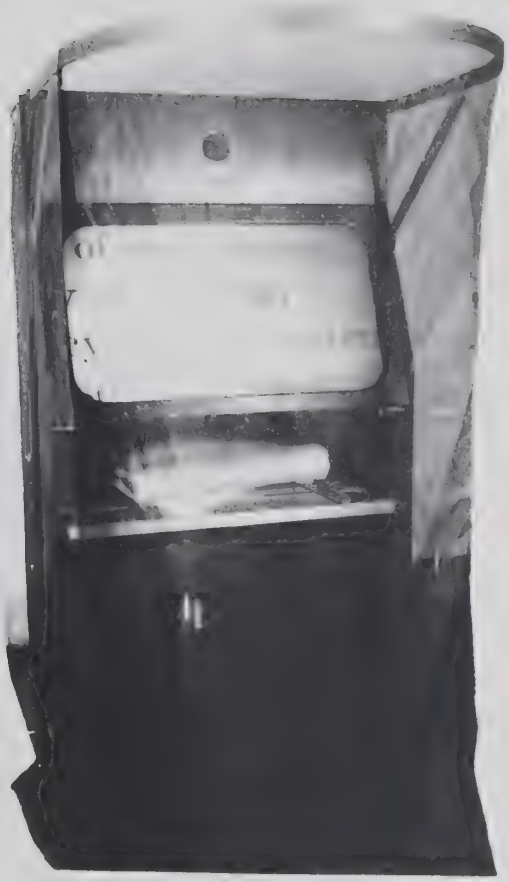


FIG. 3-8 TYPE A PROJECTION MAGNIFIER, GENERAL ARRANGEMENT

WITH 6X MAGNIFICATION



WITH 25X MAGNIFICATION

FIG. 3-9 TYPE A PROJECTION MAGNIFIER
PHANTOM VIEW OF UNIT IN USE

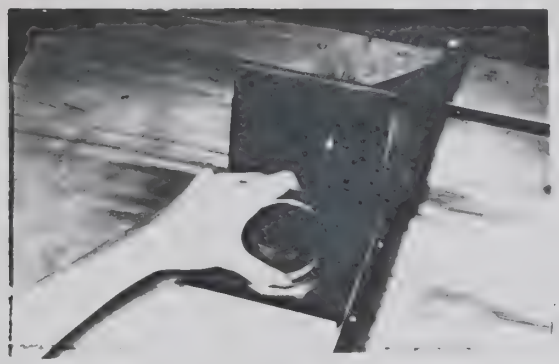


FIG. 3-10 INSTALLATION OF 6X LENS IN TYPE A OR TYPE B PROJECTION MAGNIFIER

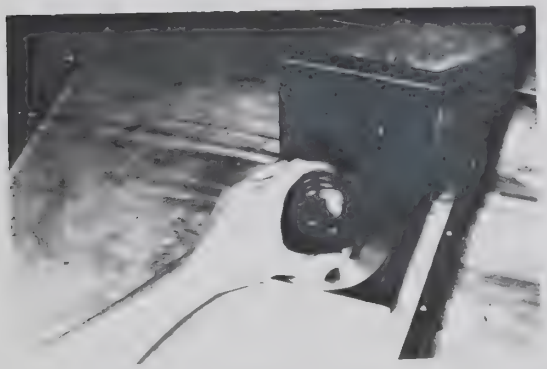


FIG. 3-11 INSTALLATION OF 25X LENS IN TYPE A OR TYPE B PROJECTION MAGNIFIER

FIG. 3-12 REMOVAL OF LAMP FROM TYPE A OR TYPE B PROJECTION MAGNIFIER

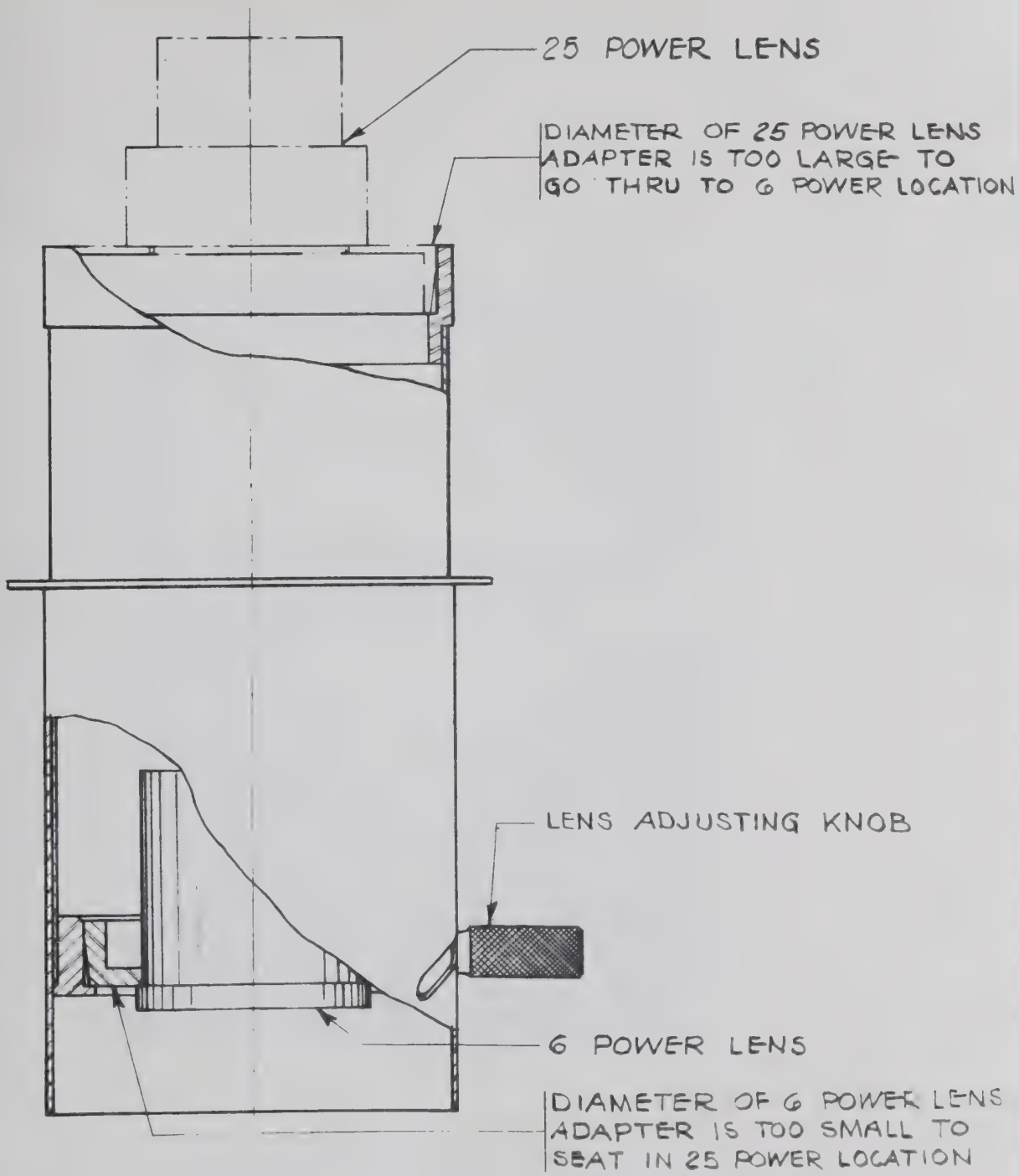

25 POWER LENS
DIAMETER OF 25 POWER LENS ADAPTER IS TOO LARGE TO GO THRU TO 6 POWER LOCATION
LENS ADJUSTING KNOB
6 POWER LENS
DIAMETER OF 6 POWER LENS ADAPTER IS TOO SMALL TO SEAT IN 25 POWER LOCATION

FIG. 3-13 FOCUSING TUBE AND LENSES

FIG. 3-14 TYPE A PROJECTION MAGNIFIER

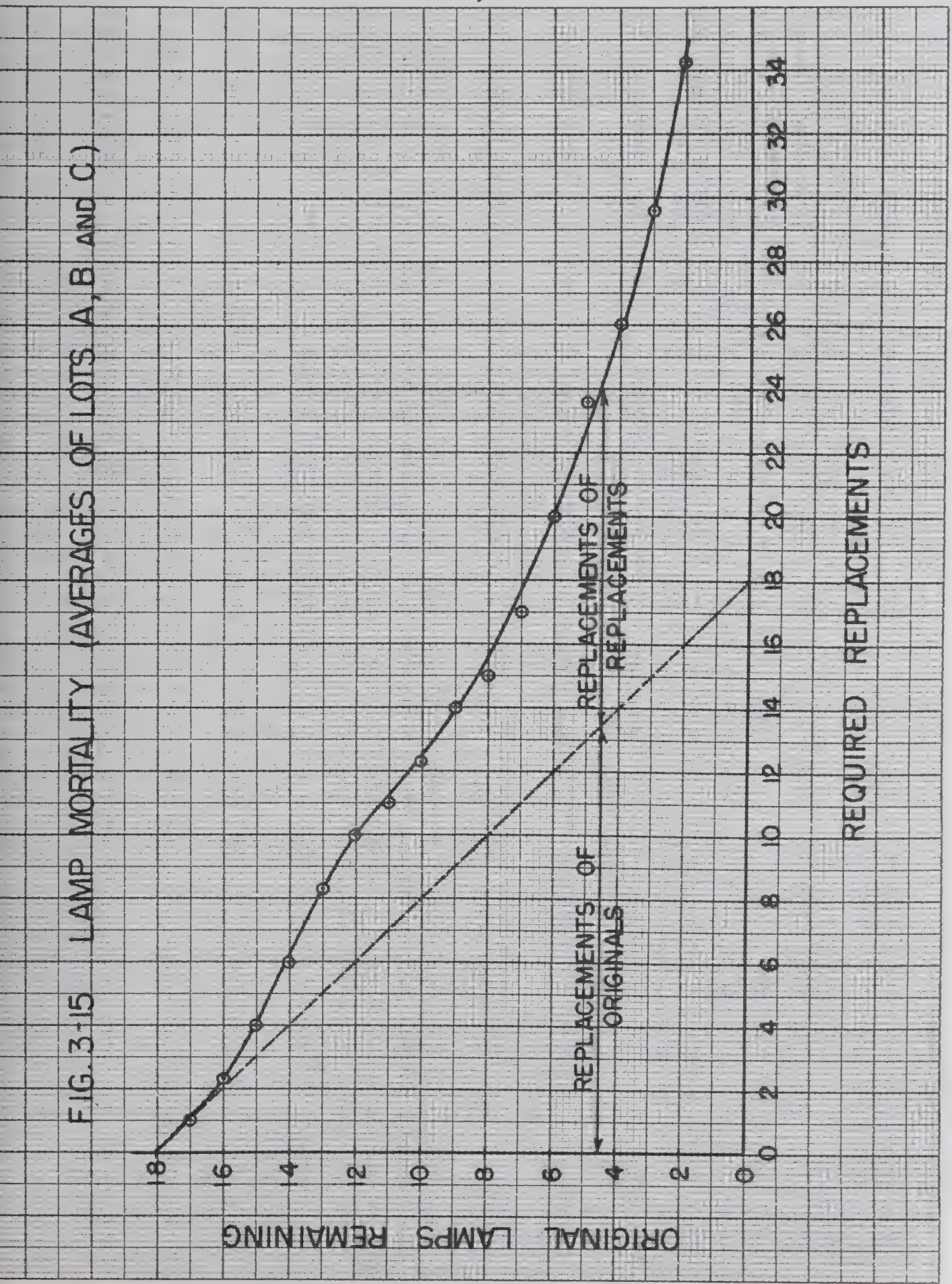


FIG. 3-15 LAMP MORTALITY (AVERAGES OF LOTS A, B AND C)

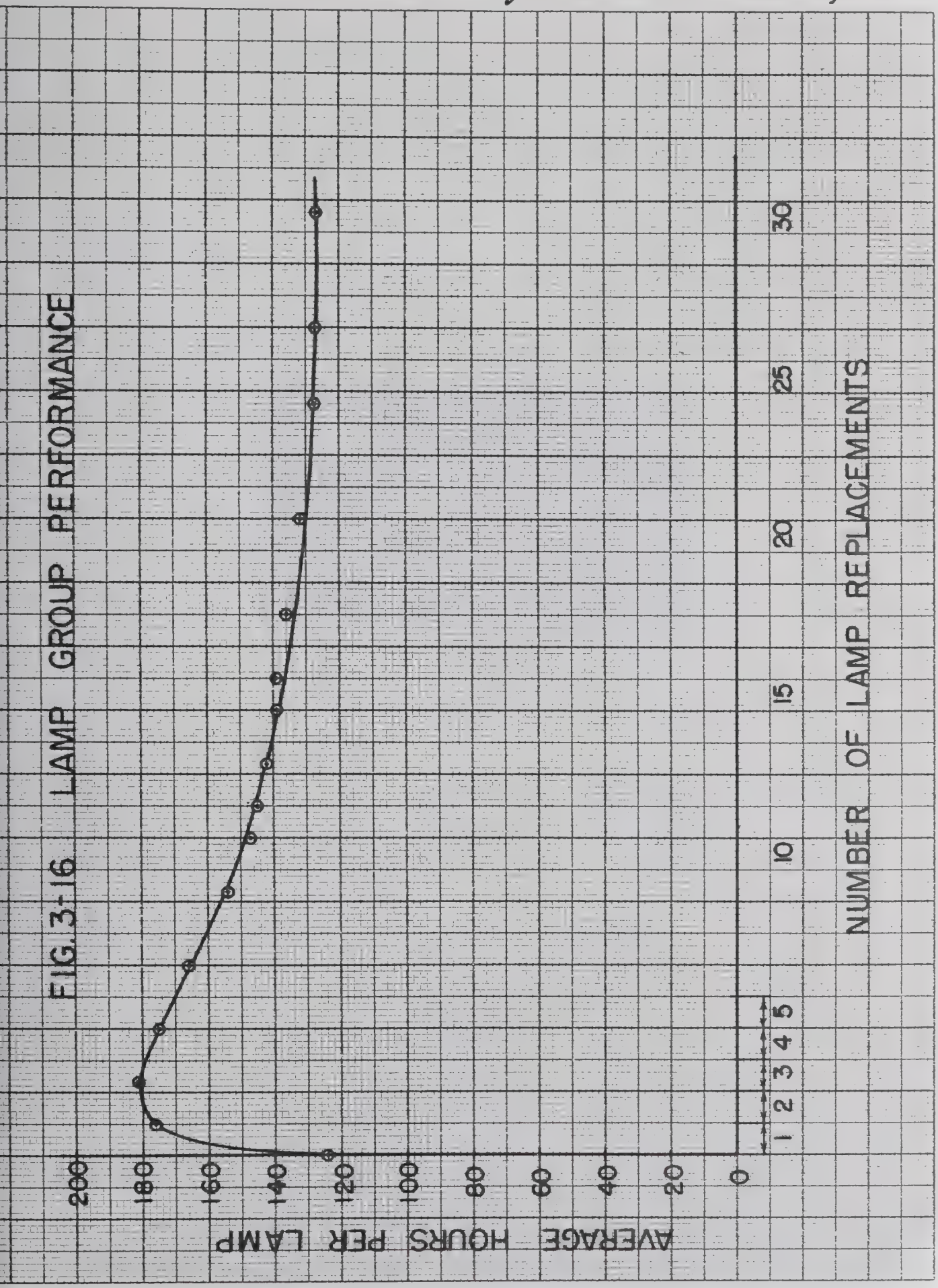


FIG. 3-16 LAMP GROUP PERFORMANCE

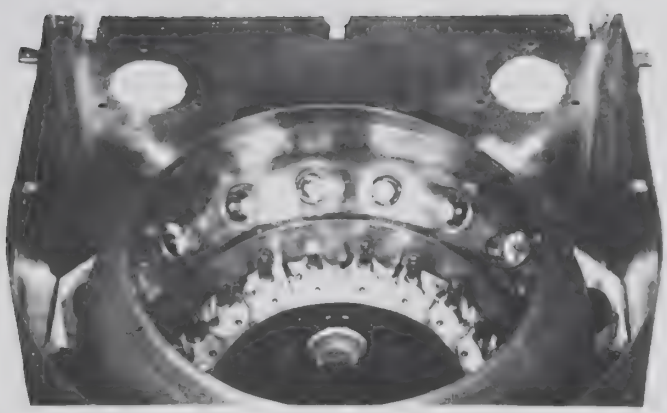


FIG 3-17 TYPE A PROJECTION MAGNIFIER, LIGHT LENS BOX

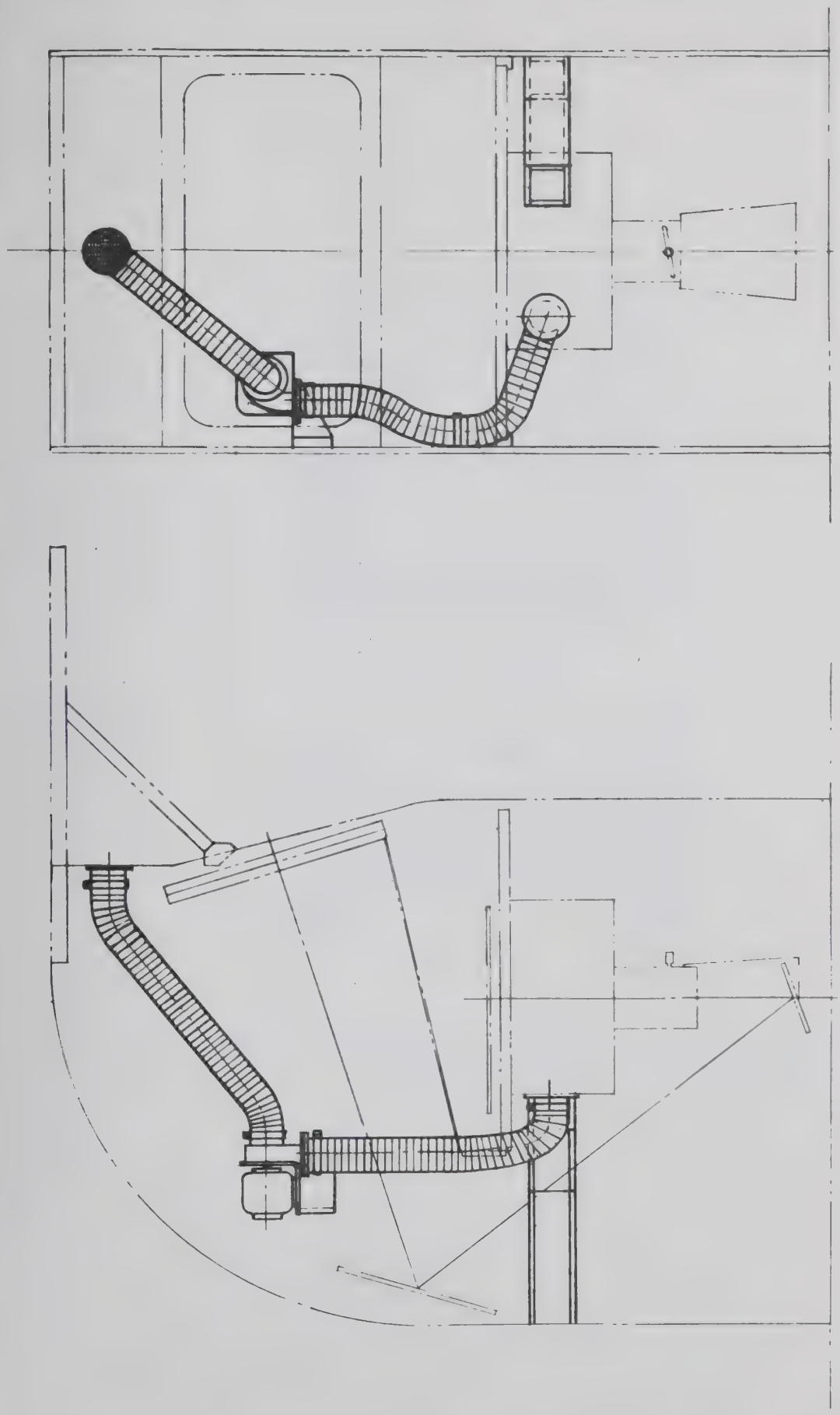


FIG. 3-18 TYPE A PROJECTION MAGNIFIER, ARRANGEMENT OF VENTILLATING SYSTEM

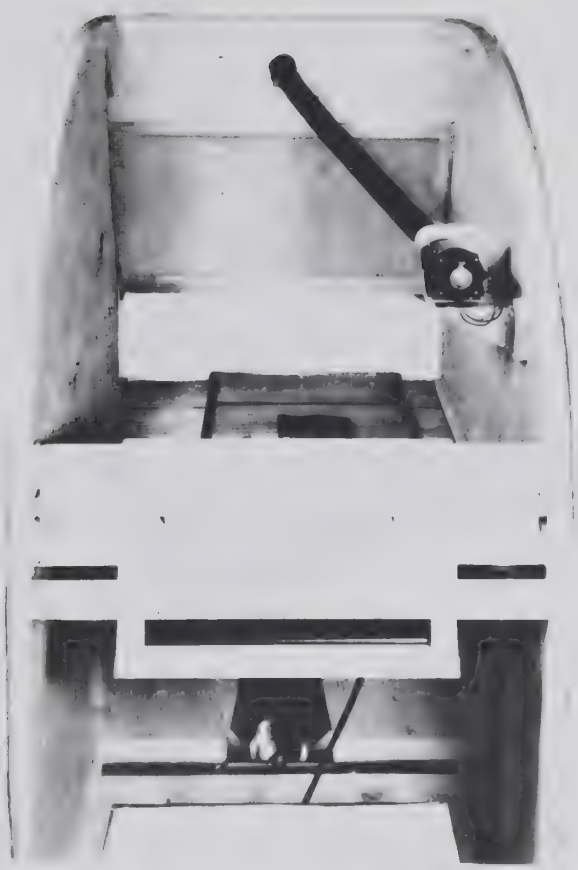


FIG. 3-19 TYPE A PROJECTION MAGNIFIER, CONSTRUCTION DETAILS

FIG. 3-20 PHANTOM SIDE VIEW OF TYPE B PROJECTION MAGNIFIER

25X MAGNIFICATION LENS

6X MAGNIFICATION LENS

FIG. 3-21 PHANTOM VIEW OF TYPE B PROJECTION MAGNIFIER

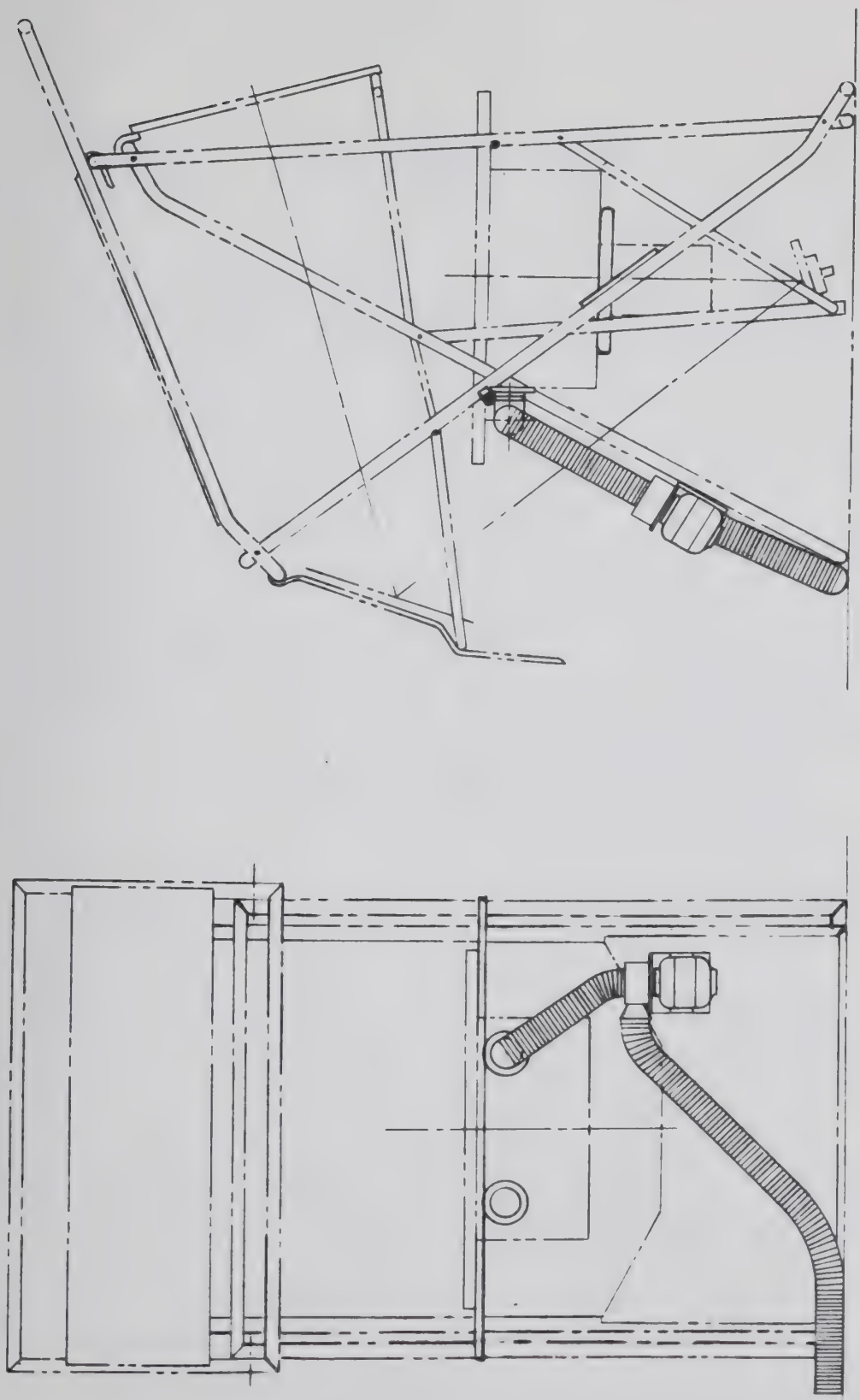


FIG. 3-22 TYPE B PROJECTION MAGNIFIER, ARRANGEMENT OF VENTILLATING SYSTEM

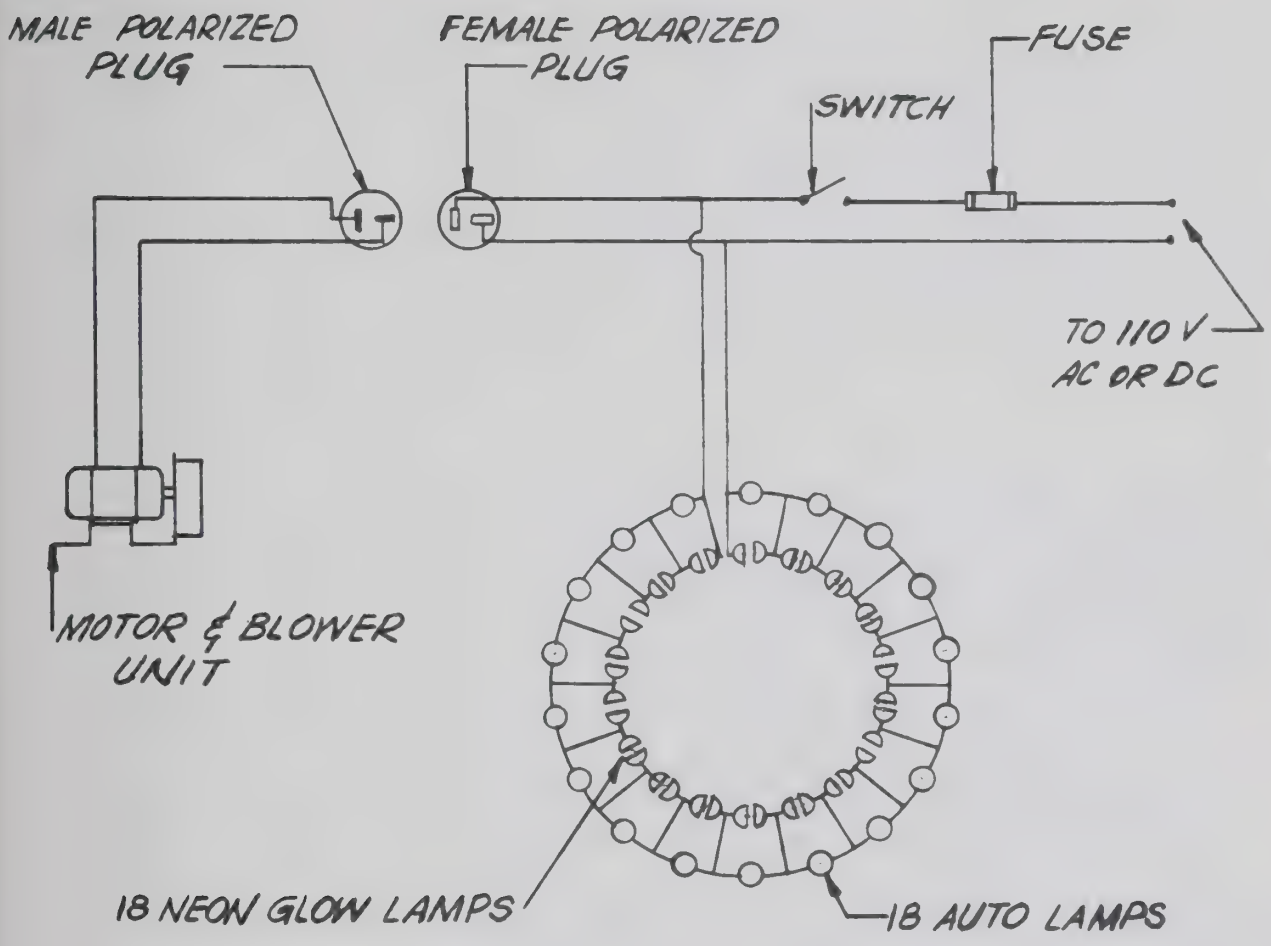


FIG. 3-23 TYPE B PROJECTION MAGNIFIER, WIRING DIAGRAM

4. VARIATIONS

It is recognized that some of the elements selected for the three models described in this report are compromises which have been dictated either by availability or in order to provide compatibility of the several elements which must function together. Alternative arrangements will now be discussed and an attempt will be made to evaluate some of their potentialities.

4.1 The Screen

To function satisfactorily in a device of this kind a translucent screen should have a high transmission coefficient and scattering qualities such as to permit reading without undue head motion. A screen of frosted glass, or frosted vinylite or cellulose acetate may produce a good image when viewed normally, but when observed from an angle, the image tends to disappear, hence if the reader has a very short eye-to-screen distance, considerable movement is necessary in order to read across the screen. Such screens eliminate the reddish lens image usually seen on a screen of standard material, but it is doubtful if the presence of this spot will seem objectionable to a reader who is accustomed to the use of the magnifier.

4.2 Magnification

The magnification ratios which have been selected for these units do not necessarily represent the most desirable selection for all projection magnifiers, however, it is advantageous from the point of view of different users of the same magnifier to be able to change from one magnification to another. There is little advantage in the use of a projection magnifier with a magnification of less than five since satisfactory results may be attained

by other means. A high magnification 1) makes reading very slow, 2) requires a large amount of light, 3) produces an image of poor print that has uneven and fuzzy edges, 4) involves smoother movement of the reading material to avoid eye fatigue. Lenses better suited to use in the projection magnifier might be designed for construction at lower cost than the commercial lenses now available, but it has not been possible to have this done under the present contract.

4.3 Optical Path

Several alternative optical paths are shown in Figures 2-1, 2-2, and 2-3 and no claim is made that the one selected is the optimum. The system chosen efficiently utilizes the cabinet space, that is, the light path goes almost all the way to the floor and almost all the way to the top of the cabinet. At the same time, it goes from the very front to the very back. At least two mirrors are desirable if the material being scanned is to be near the screen. The minimum length of optical path is determined by the requirements of back focus to permit illumination of the page and those of front focus to provide the necessary magnification ratio.

4.4 Location of Book

Several of the schemes sketched in Figures 2-2 and 2-3, taken in connection with paragraph 4.3, suggest that the preferred position of the reading material is horizontal and face up. This is the most natural position for those able to read without the magnifier and is the easiest position from which to turn pages, however, the illuminating system and the lens would then interfere with placing the screen in the best position, unless a complex system of mirrors which would obviate this difficulty were worked out.

4.5 Method of Scanning

Movement of the material being scanned, as opposed to movement of the optical system, was decided upon because it appeared to present fewer difficulties. If it were desirable, this method of scanning might easily be modified so as to include remote control, or movement in discontinuous jumps with which the movement of a shutter might be synchronized so as to minimize eye strain. Neverthless, a satisfactory system employing movement of the optical path might be developed and until considerable thought has been given to the feasibility of such an arrangement no final judgment should be passed, even though such a scanning device seems to be inherently more expensive, sensitive to shock and misalignment and more difficult to control than the system employing fixed lenses and optical elements.

4.6 Illumination

The three models which have been described represent two very different philosophies with regard to the design of the illuminating system. The horizontal screen projection magnifier could hardly be more simple or more rugged in its illuminating system, whereas the other two models represent a serious attempt to attain high illumination efficiency by the use of standard components of low cost and easy availability. The disadvantages of using eighteen headlight bulbs in series are that maintenance cost is higher, replacement technique is more complicated, the failure of one lamp shuts off the entire illuminating system. Fluorescent and vapor lamps of extremely high efficiency supplying high candle power from a small area may be the answer to the problem. The development of such light sources is a long and costly process which would be justified only if a large number of the units were to be constructed.

4.7 Hood

The hoods supplied with the two vertical screen models, although satisfactory, are not ideal and could be dispensed with if the unit were housed in a booth with rigid sides. This would make possible, also, the installation of a better ventilating system for the reader.

4.8 Ventilating System

The difficulty of obtaining both motors and blowers at this time made it impossible to install a system with a lower noise level brought about by lowering both rotation speed and air velocity through the ducts. More satisfactory ventilation might be achieved by employing two separate systems, one for the person using the device and one for the dissipation of the heat from the lamps.

4.9 Safety

Protection of the reader requires that the unit must 1) be fireproof, 2) be constructed of unbreakable elements, 3) provide proper ventilation of the reader, 4) make exit from the hood as simple as possible. In the units described above escape is accomplished merely by lifting the hood.

4.10 Cabinet

Consideration has been given to the construction of units exclusively with sheet metal and structural angles. The cost per unit will then decrease as the number of units constructed increases. The cabinet could be designed for easy knockdown to permit shipment whether the fragile elements are removable for separate packing or are mounted rigidly in place.

5. FUTURE DEVELOPMENTS

5.1 Basis of Recommendations

Although the advantages and disadvantages of the units which have been manufactured under this contract will be brought to light by the persons who are to use these magnifiers, there are certain lines of future development, the validity of which will not be affected substantially by the outcome of such personal evaluation. These are considered in the following paragraphs.

5.2 Lenses

Investigation has shown that the development of special lenses, by optical manufacturers, to suit the unique needs of this magnifier is feasible and economical if large quantities are to be constructed, but it is not economical to use lenses that are of higher quality than necessary. Since the lens is a major item of expense, a reduction in cost without sacrifice of image quality is a worth-while goal.

5.3 Location of Book

While it has been established that the ideal book location is that employed in the Type A and Type B magnifiers, provided they are to be used for reading only, this is not necessarily the best location if the magnifier is to be used in conjunction with a writing device, such as a pencil, a pen or a typewriter. If the projection magnifier were designed so as to project upon a portion of the screen material already written, and upon the remainder of the screen, material being written, then letter-writing, copying and sketching by the semi-blind would be feasible. This would require a table conveniently placed both for the writer's use and also for scanning. If a typewriter is to be employed, it must stand in front of the typist, hence it

would probably occupy the space now assigned to the book and force the removal of the book to some other location.

5.4 Method of Scanning

A more comprehensive investigation of the possibility of scanning by means of moving the optical system is justified because of the gain which would result from book placement face up. Although movement of the optical system now appears to involve the addition of sensitive and expensive apparatus, the problem of designing a satisfactory system of this type may not be insurmountable.

5.5 Illumination

The development of special light sources is almost invariably a long and costly procedure, but the use of proper optical elements may permit the construction of a satisfactory illuminating system more rugged and more easily maintained than the present one. The illuminating system is a feature of sufficient importance to the usefulness of the projection magnifier to warrent the expenditure of much effort in the attempt to make it more efficient.

5.6 Ventilating System

The ventilating system used with the Type A and the Type B magnifier does not permit the temperature under the hood to rise more than a few degrees above that of the room, but, on a hot summer day these few degrees may prove too much for comfort. Future units should be designed for a considerably lower noise level and increased rate of change of air around the reader.

5.7 Cabinet

All metal construction of the cabinet permits maximum safety, maximum durability, light weight, great comfort, low cost, and good styling.

A cabinet made of metal sheets with stampings for stiffeners could be fabricated with ease were a sufficient number to be ordered to justify the cost of the necessary dies. Complete redesign of the projection magnifier from an engineering standpoint will be necessary if the change from wood to metal is made. It is possible that a sheet metal collapsible magnifier could be designed and constructed but much preliminary work must preceed construction.

5.8 Major Changes

A need exists for a projection magnifier to be used for small classes of the semi-blind. Groups of three to eight students standing several feet from the screen should be able to read the projected image at about twenty-five times magnification. A classroom projection magnifier should be entirely different in general arrangement from the unit to be used by an individual in that the screen should be larger, and the location of the material to be projected and the method of scanning it should be such that the teacher can conveniently control the magnifier while facing the students. Provision should be made for pointing on the screen while the unit is in operation, without discomfort to the instructor.

The three models described in this report were designed for fabrication as experimental units, hence extensive redesign would be essential in the case of mass production.

APPENDIX A

Instructions for Unpacking, Setting Up and Operating the Horizontal Screen, Rigid Frame Projection Magnifier

The magnifier should be uncrated carefully and all separate pieces removed from the packing and laid aside. Each aluminum angle leg should be attached by means of a flat-head screw which is to pass through the angle and into the hole drilled in the corner of the frame and tapped to receive the cap screw. The brace is fastened to the horizontal angle frame member by means of a knurled brass screw and washer. The four legs are not identical. There are two sets, each of which consists of a pair of identical legs. If the legs are examined from the end nearest the drilled hole, it will be seen that two of them have the extensions attached to the right leg of the angle and two have the extensions attached to the left leg of the angle. The right-hand ones go on the right side of the projection magnifier, one at the front and one at the back. The two left-hand ones are similarly attached on the left-hand side of the magnifier. The front of the magnifier may be identified as that side having two access doors (Fig. A-4).

When the legs have been securely attached, the table top may be assembled. First, place one of the strips, to which are pinned the rollers, on each of the two fixed tracks which run left and right in recesses on the table top, Next, place the moving frame over the table top so that it rolls freely right or left. Be sure that the gusset plates are at the rear of the moving frame. One roller cage should next be placed on each moving track and the pyrex plate should be cleaned and placed on the rollers. This completes the assembly of the table top, and when it has been properly done, it is possible to move the frame back and forth over the entire top and to move the

pyrex plate from the very front all the way to the rear (Figs. A-2 and A-3).

The screen, which is on top of the left-hand side of the unit, should next be uncovered and folded forward on its hinges. The large mirror which is accessible from the top should be examined and cleaned with a lintless cloth, if necessary. The screen should be folded back until the flap on the screen frame rests against the plastic stop-plate permanently attached to the unit. The screen frame is then slightly inclined. At this point in the setup all three access doors should be open.

Remove the lens cover and clean the lens with lens paper if necessary. From the bottom access door the lens diaphragm, controllable from a ring within the lens mount as are many camera lenses, should be turned until the diaphragm is wide open. This may be checked by looking at the lens through the port in the table top. If moderate illumination is permitted to fall upon the screen, the diaphragm will be clearly outlined within the lens. Rotate the diaphragm control ring until the diaphragm is wide open.

Place the hood frames in the holes provided. Place the hood over the hood supports so that the flaps are at the front.

Check the condition of the small mirror through one of the lower access doors and dust, if necessary. Plug in the line cord to any 110 volt source. Turn on the toggle switch located on the outside of the lens house near the place where the line cord goes into the unit. Check to see that all lamps are on and dusted. Place reading material face down on the pyrex plate and cover with the sponge rubber, (Figs. A-2, A-3). With the light in the room subdued, examine the image upon the screen, being certain that the reading material is flat against the pyrex plate. If the lens must be adjusted: 1) look for the set screw (Fig. A-5) in the slot of the lens holder, accessible in the upper front access door and loosen; 2) grip the lens from underneath and

raise or lower by turning slightly; 3) when the image is sharp, tighten the set screw.

It is well to check the diaphragm opening after having focused the lens because the possibility exists of inadvertently moving the diaphragm in the process of focusing.

If necessary, the small mirror may be adjusted as follows (Fig. A-6):

(1) To center mirror, loosen set screw (A) on positioning ring, loosen knurled head screw (B) and set the mirror. Tighten knurled head screw, set the ring, and tighten set screw.

(2) To set the angle of the mirror (horizontal axis) loosen slotted screw (D) from the rear of the mirror house, loosen knurled head screw (C) accessible from the front, and adjust. Tighten first knurled head screw and then slotted screw.

Operating Procedure

Turn on switch. Have material face down on pyrex plate and covered with sponge rubber. Place the head within the left-hand hood. Put the right hand under right-hand hood so that it rests upon the rubber mat. Pressing firmly on the mat over the reading material, rotate until the lines are straight on the screen. For actual reading, it is most convenient to rest the hand upon the table top and with the fingers guide the material from side to side and up and down. If the extreme travel of the table top does not permit examination of the material to be read, the paper must be shifted to a new position on the pyrex plate. It is necessary that the light be subdued in the space in which the magnifier is operated and that the hood be tight enough around the operator to exclude unwanted illumination. The purpose of the hood over the right-hand

section of the table is to prevent the light incident upon the pyrex plate from escaping to the other side.

Maintenance

1. Dust the mirrors regularly.
2. Clean the lens regularly with good lens tissue checking each time to see that the diaphragm is wide open.
3. Keep the pyrex plate clean.
4. Dust both sides of the screen frequently.
5. Keep the bulbs clean and replace when blackened.

FIG. A-1 HORIZONTAL SCREEN, RIGID FRAME PROJECTION MAGNIFIER

FIG. A-2 PHANTOM VIEW OF MAGNIFIER IN USE

FIG. A-3 DETAIL OF TABLE TOP

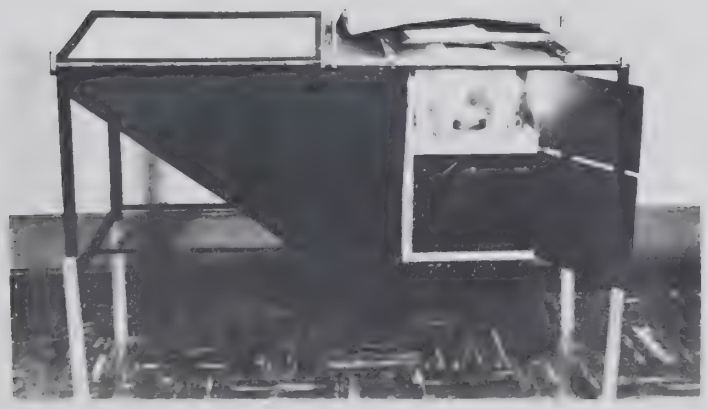


FIG. A-4 ACCESS DOOR OPEN, HOOD REMOVED

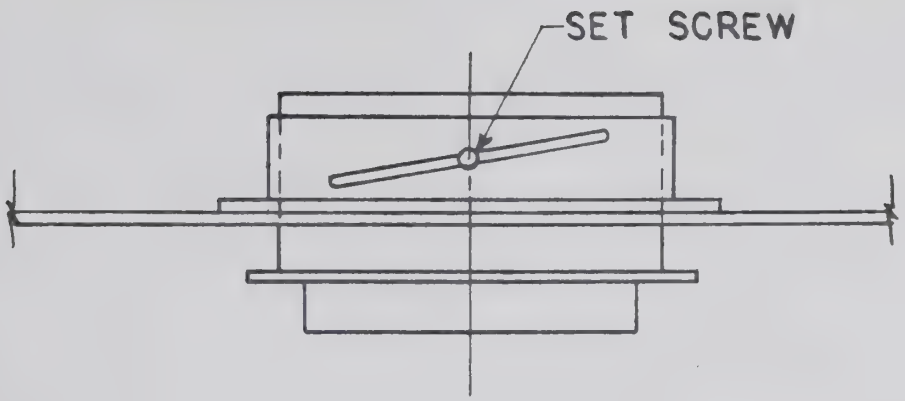


FIG. A-5 LENS ADJUSTMENT

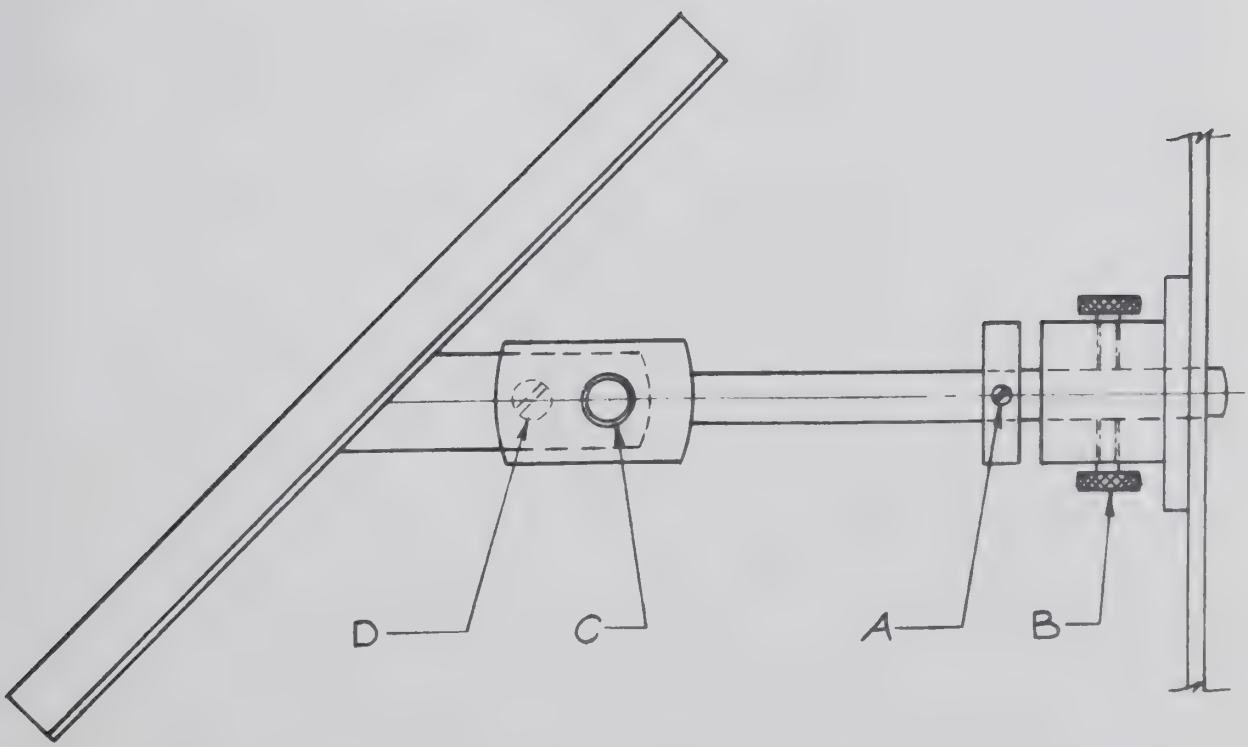


FIG. A-6 MIRROR ADJUSTMENT

A- SET SCREW
B- KNURLED HEAD SCREW
C- KNURLED HEAD SCREW
D- SLOTTED SCREW

APPENDIX B

Instructions for Unpacking, Setting Up and Operating the Type A Vertical Screen, Rigid Frame Projection Magnifier

The magnifier should be carefully removed from its crate and separate pieces removed from the packing and laid aside. It will be necessary first to remove the separate box containing the lens before the magnifier cabinet may be removed from its crate. The three members which form the hood support should be laid aside and all checks and stuffing should be removed from the table top. The hood will be found stuffed in the space between the table top and the horizontal light shield.

The glass plate should move freely on its tracks, both from side to side and back and forth. If the glass plate does not roll easily, remove the glass plate, the two strips to which are pinned the rollers, the moving track assembly and the second set of rollers. Reassemble the table top as follows:

First, place one of the strips to which are pinned the rollers on each of the two fixed tracks which run left and right in recesses in the table top. Next, place the moving frame over the table top so that it rolls freely right or left. Be sure that the gusset plates are at the rear of the moving frame. One roller cage should next be placed on each moving track and the pyrex plate should be cleaned and placed on the rollers. This completes the assembly of the table top, and when properly done, it is possible to move the moving frame from right to left over the entire top and to move the pyrex plate from the very front all the way to the rear. (Fig. B-2).

The four screws in the front of the screen frame should be loosened and the screen frame and screen removed. Reaching in through the opening in the front of the cabinet, access is gained to the nuts which are attached to the four large bolts located on the sides near the top at the front of the magnifier. The semicircular hood support may now be slid into position by setting the ends in the slots cut in the front of the magnifier cabinet, and pushing toward the rear. The four holding bolts should now be pushed back into the holes from which they were removed, and through the holes drilled in the hood support. The washers and nuts may be applied from inside the cabinet.

The screen and screen frame should next be replaced and the four holding screws tightened in position. If the holes in the removed piece of the screen frame do not seem to match those in the fixed portion, rotate the screen frame 180° and try again. The sliding bolts on the bottom of the screen frame should next be pulled inward. The screen frame swings outward about an inch on its top hinges. The inclined baffle directly behind the screen frame may now be pushed up and out of the way, as it swings on hinges at the rear. The screen frame should now be swung to the rear on its hinges until it is out of the way.

The two hood support brackets should be put in place. They are attached to the hood support by means of brass round-head screws and to the cabinet by means of machine screws and bolts. When correctly assembled the brackets are outside of the little ears attached to the hood support and inside of the fastening plates by which they were attached to the cabinet. The upper ends have been so shaped that they fit without interference at the hood support. The two flat-head machine screws on each side of the cabinet should be separated

from the nuts and washers and the brackets put in place over the holes from which the screws were removed. The screws should then be replaced so that the flat heads are inside the cabinet in the countersunk holes, which permits the screen frame to slide past. The washers and nuts may then be applied outside. With the screen still swung out of place, remove the glass plate from its track or tip it up at the back so that the cover of the port in the table top may be swung over. The lens should then be grasped by the barrel so that the stainless steel adapter is down, and adapter and lens gently lowered into the lens tube through the port until the adapter seats at the bottom. Leave the cover open (it is closed only when the twenty-five times magnification lens is used), replace the glass plate so that it rolls freely in both directions. Place a book or other reading matter upside down on the glass plate and cover with the sponge rubber provided. Pull the screen frame forward, reach in and pull down the inclined baffle. Note that the forward edge of the baffle is beaded and that the rear of the screen frame is grooved to receive the bead and to form thereby a light-tight seal. Swing the screen frame back into place so that the bead in the baffle is in the groove in the screen frame. When this has been correctly done, the slide bolts may be easily pushed outward into the holes in the side of the cabinet. If the slide bolts do not readily go into the locked position, the baffle is probably not in the groove in the screen frame. Move it slightly and try again.

The hood may now be placed over the hood support and attached to the cabinet by means of the fasteners. When correctly assembled, the flap is on the left-hand side. (Figs. B-3, B-4).

The line cord may be plugged into a 110 volt AC or DC source. The switch, which is located under the table top on the transverse plywood dividing wall to the left of the light lens box, may be snapped on. The image of the reading material should then be projected upon the screen and should be focussed

by rotating the focusing tube by means of the focusing lever which is accessible right under the light lens box. (Fig. B-2).

An ordinary 18-inch chair may be used with the magnifier.

For routine operation the material to be read should be placed face down on the pyrex plate and covered with the rubber mat. Rest the hands upon the table top. The fingers may conveniently be used to move the glass plate, book and mat from side to side, and up and down in order to cover entire pages. If books with stiff bindings are read, the printing near the center of the book may be projected out of focus. Slight pressure on the rubber mat over the book will generally flatten it enough to bring this material into focus. When a page is to be turned, one hand may be slid under the mat and the page turned by folding upon itself so that it slides across the glass plate from one side to the other. With very little practice, proficiency in the technique of page turning may be attained.

If the lens is to be changed, the latches on the screen frame should be pulled in, the screen frame swung forward slightly, the light baffle swung up, and then the screen swung far back. The glass plate should then be pushed to the rear and lifted up by the front edge. Through the port one lens may be removed and the other inserted. It should be noted that the six times magnification lens seats at the very bottom of the lens tube, whereas the high magnification lens seats at the top. The lens adapter for the twenty-five times magnification unit is too large to pass through to the bottom. The lens adapter for the six times magnification unit is too small to seat at the top. One lens only should be used at a time. The port cover should be closed when the high magnification lens is in place. It remains open when using the low magnification lens. After the change has been made, the brass plate should be lowered and

the screen frame and light shield put into place. It may be necessary to refocus after changing the lens.

Maintenance

When the unit fails to operate after having been connected to a live outlet and switched on, listen for the sound of the blower. If this cannot be heard, check the fuse which is accessible under the table top at the left of the light lens box, just beside the switch. A blown fuse indicates that something is wrong and an attempt should be made to locate the short before resuming operations. If the blower is running, swing back the plywood baffle and screen frame as in changing a lens and look through the open port in the table top. A glowing neon bulb indicates a failed lamp. Note the location of the glowing bulb, turn off the power, remove the bulb immediately adjacent to and on the same radius as the glowing neon light, and replace with a new one. Turn on the switch and if the illuminating system operates satisfactorily, resume use. More than one bulb can fail at a time. The bulbs to be used in this apparatus are regular auto head-lamp units designated by all manufacturers as No. 1133, single contact, bayonet base, 6 to 8 volt, 32 candle power lamps. It is most economical and satisfactory to buy these bulbs in groups of twenty, to replace failed lamps twice, but upon the third failure, which would mean the twenty-first bulb since eighteen are active in the illuminating system at a time, to throw away all remaining bulbs, good and bad, of the lot and start with a new group of twenty. Two spare bulbs may be stored in extra sockets located to the right of the light lens box, just under the table top. The reflector and bulbs should be dusted regularly. The lens should be cleaned with good lens paper. The two mirrors should be cleaned with surgical cotton and non-alkali soap. If the soap does not remove all of the marks from these front

surface aluminized mirrors, a 10 percent nitric acid solution may be used. Care should be exercised to see that it does not remain on the surface too long and that the solution does not remain long on the hands of the person doing the cleaning. The upper mirror is accessible by first opening the latches of the screen frame, swinging the screen frame slightly forward as usual, and then swinging down, rather than up, the plywood light shield. The screen frame should then be swung up to the rear and the upper mirror will be clearly visible and accessible from the front. The lower mirror is reached by slightly raising the sheet metal shield located at the front of the cabinet, below the lens tube. It will be noted that the edges of the shield are slotted just below four clamps attached to the vertical plywood wall. The shield is lifted up until the clamps are opposite the holes cut in the shield. The shield may then be pulled forward and out of the way, exposing the lower mirror.

The blower motor should be oiled at both bearings regularly. It is accessible by the same means as used to gain access to the large rear mirror. If at any time the blower does not operate when the lights are on, cease operation and have the blower repaired before proceeding. Without the blower, the cabinet will become uncomfortably hot and the heat generated in the light lens box will not be dissipated.

Clean the screen as frequently as is necessary with a clean cloth. Soapy water may be used if needed. The pyrex plate should also be kept free of dirt and finger marks.

FIG. B-1 EXTERIOR OF TYPE A PROJECTION MAGNIFIER

FIG. B-2 FRONT VIEW HOOD REMOVED

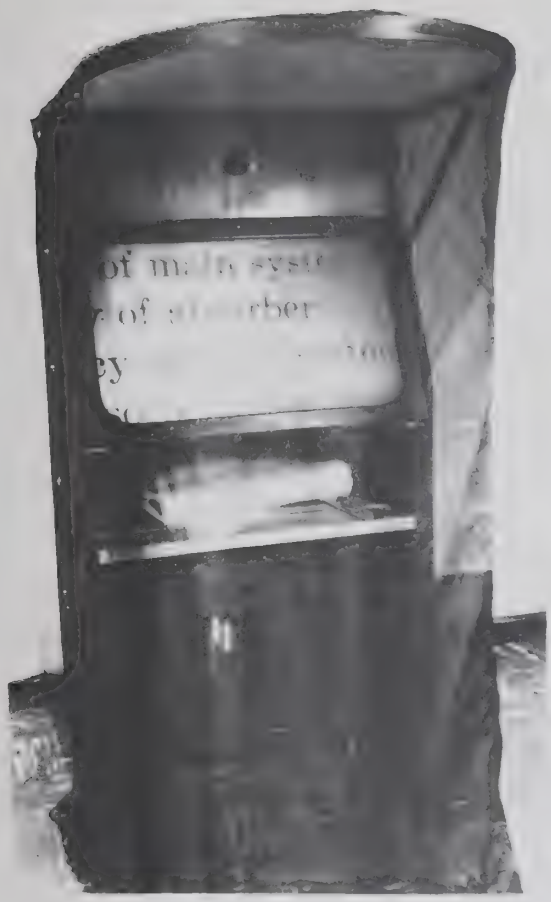


FIG. B-3 PHANTOM VIEW
USING 25X MAGNIFICATION

FIG. B-4 PHANTOM VIEW
USING 6X MAGNIFICATION

APPENDIX C

Instructions for Unpacking, Setting Up and Operating the Type B Vertical Screen, Collapsible Frame Projection Magnifier.

The magnifier parts should be carefully removed from the crates in which they are shipped and the separate pieces laid aside. It may be necessary to remove some of the chocks which hold the optical parts rigidly in the case.

The frame should be set vertically upon the floor with the blower and motor at the bottom and the large aluminum sheet at the top. It should then be opened slightly so that the frame supporting the blower and motor is one leg of the assembly and the frame carrying the largest aluminum sheet is the other. The small frame which is pivoted near the top of the assembly should be swung slightly (see Fig. C-3). The assembly, consisting of all pieces but the one with the large aluminum plate, should be held steady and the big frame swung up around its pivot point as shown in Figure C-4 until it is above the horizontal. The large frame should then be pushed to the back so that the frame opens as shown in Figure C-5 which is a view of the operation in three stages. Figure C-6 shows the frame half open and it may be seen that the frame carrying the blower is to be held steady and the others opened around it with the large sheet of aluminum sliding along the top of the uppermost horizontal member until it hooks. The frame may then be rested upon the floor and the accessories installed.

The yoke, to which is welded at each end a length of half-pipe, should be placed on the outermost inclined frame members as far down as possible. It will be necessary to remove the wing-headed screws from the bronze

clamping ring and to open the ring before the half-pipes may be slid over the pieces upon which they rest. It will then be resting upon the smallest diagonal piece as shown in Figure C-7.

The light lens box is next to be installed. This is accomplished by sliding the light lens box into the supporting yoke in two motions as shown in Figure C-7. The box is grasped at the bottom and placed inside the frame so that the telescoping tubing which extends out the bottom is in back of the horizontal cross-wire at the front of the frame. The entire box is tilted toward the rear so that it slides under the heavy crossbar. The telescoping tubing should then be dropped into the hole in the yoke and the light lens box lowered until it rests on the yoke. Note that the two angles attached to the bottom of the light lens box are to go inside the yoke and the box should be pulled forward until those angles contact the rear side of the forward half. The yoke may then be grasped from the top and slid upward to the rear along the pipes on which it rides until the lower edges of the half-pipe have passed over the screw heads permanently attached to the outside diagonal upon which the yoke rests. The yoke should then be released so that it rests upon the two screw heads as shown in Figure C-8. The wing-headed screws should be installed in the bronze clamp and tightened to hold the yoke securely in position in the frame.

The hoses may next be installed. From the rear, one end of the short hose is slipped over the right-hand brass outlet on the light lens box and the other end slipped over the blower suction. Before the clamps are tightened, the hose should be twisted at the blower so that it is as close to the outside of the frame as possible in order to minimize the possibility of the hose interfering with the light path. The wire clamps on the attached hose should be

tightened. The longer length of hose should be slipped over the tubing at the blower discharge fitting and the hose permitted to run along the aluminum stiffener plate and the floor. Figure C-9 shows the hoses installed. Figure C-9 also shows the correct location of the wires from the light lens box. They should be resting on the stiffener plate to which the blower is attached and outside of the blower. The plug attached to the blower motor should be inserted in the mating plug attached to the short line from the light lens box.

The table top should next be installed. It should be grasped from the front, the edge nearest the name plate, and placed within the front vertical frame above the light lens box and horizontal tie rod. It should then be slid to the rear between the strap pieces which support the lower mirror under the tie rod to which the strap frame is attached and over the heavy bar stiffener at the rear. It will be necessary to press down on the front of the table top as shown in Figure C-10 so that the rear of the table top does not rest on the light lens box. The table top in this inclined position is then pushed to the rear as far as it will go and released. It will then assume a horizontal position. Note that under the table top near the forward edge a hook has been placed on each side. It is intended that the table top be slid on so that the slanting tie rod is between the table top sides and these hooks. The heavy stiffener at the rear is notched to receive the table top protrusions when the installation has been correctly made. The table top assembly may be completed by placing one set of rollers on each of the two rails in the table top. The sliding frame should then be placed in these rollers with the gusset plates to the rear so that it rolls freely from right to left. The second set of rollers should then be placed on the tracks in the moving frame, the port in

the table top should be open and the proper lens installed by grasping lens and mount by the lens barrel and lowering through the port in the table top until the lens seats. The pyrex plate should be cleaned and placed on top of the rollers in the moving frame. The small cloth sack with the weighted hem should be slipped over the intermediate pivoting frame so that the flap hangs over the pivoting bar and down to the table top (see Figs. C-11 and C-12).

Installation of the rear mirror is accomplished in three steps. The mirror frame having long aluminum strips attached to both sides is grasped near the bottom, as shown in Figure C-12, and from the back of the magnifier frame the hooks in the aluminum strip are placed on the horizontal bar shown. The mirror frame is then lowered until the strips either rest upon the bar at the rear, as shown in Figure C-12, or the mirror hangs free from the top.

The lower mirror should next be installed. It is mounted on a long wooden piece to which a shaped aluminum sheet is attached at each end. The wing nuts should be removed from the screws near the bottom of the inside light diagonal members. The lower mirror should then be placed on these light diagonals so that the screws protrude through the holes in the aluminum side pieces. The wing nuts should be replaced. The assembly should now look like that shown in Figure C-13.

The last piece to be assembled is the screen and screen frame. The screen frame is grasped at the sides and hooked on the horizontal pipe of the frame which supports the blower and motor, as shown in Figure C-13. The hood should then be assembled over the frame with the flap directly in front of the screen and the hard side of the cloth out. Any 18-inch chair may be placed in front of the screen for the use of the reader. The material to be scanned is placed face down upon the pyrex plate and covered with the rubber pad provided.

When the unit has been plugged into any 110-volt AC or DC source, a flip of the switch located in front of the light lens box will turn on both the illuminating lamps and the blower.

Focusing is accomplished by means of the focusing lever located on the lens tube and accessible from the front of the unit (see Fig. C-1). It is important that the light horizontal frame be pulled down as nearly horizontal as possible in order to position correctly both the large mirror and the screen.

In operation the hands should rest upon the table top and the fingers may lightly hold the sponge rubber, as shown in the phantom view, Figure C-2. Slight movement of the hands will change the area being scanned so that the reader may progress from line to line and from column to column. If the material appears twisted on the screen, slight pressure on the rubber mat over the printed material and twisting will bring it back into alignment. When a page is to be turned the hand must be slid under the mat and the page folded over itself and to the other side.

The units have been made so that they will operate with either six times magnification or twenty-five times magnification (see Figs. C-1 and C-14). A lens is removed by grasping by the barrel through the port in the table top and lifting out. It is replaced by the reverse process. (See Figs. C-15, C-16, C-17). The cover of the port should be closed when using the high magnification lens and open when using the low magnification lens.

Maintenance

If the unit fails to operate after having been connected to a live outlet and switched on, listen for the sound of the blower. If this cannot be heard, check the fuse which is accessible from the rear of the light lens box. A blown fuse indicates that something is wrong and an attempt should be made to

locate the short circuit before resuming operation. If the blower runs but the lights do not work, remove the screen frame, swing up the cloth sack and its frame, remove the pyrex plate and look down through the port in the table top. A glowing neon bulb indicates a failed lamp. Note the location of the glowing bulb, turn off the power, remove the bulb immediately adjacent to and on the same radius as the glowing neon light, and replace with a new one. Turn on the switch and if the illuminating system operates satisfactorily, resume use. More than one bulb may fail at one time. The bulbs to be used in this apparatus are regular auto head-lamp units, designated by all manufacturers as No. 1133, single contact, bayonet base, 6 to 8 volt, 32 candle power lamps. It is most economical and satisfactory to buy these bulbs in groups of twenty and replace failed lamps twice, but upon the third failure to throw away all remaining bulbs of the original group of twenty. The reflector and bulbs should be dusted regularly. The lens should be cleaned with good lens paper. The pyrex plate should be kept clean and the two mirrors should be cleaned with surgical cotton and nonalkali soap. If the soap does not remove all the marks from these front surface, aluminized mirrors, a ten percent nitric acid solution may be used.

The blower motor should be oiled at both bearings every month.

Clean the screen as frequently as necessary with a clean cloth.

WARNING: It is not desirable to operate the unit on a metal floor as the operator may suffer an electric shock when changing bulbs if he is grounded and the switch is not turned off.

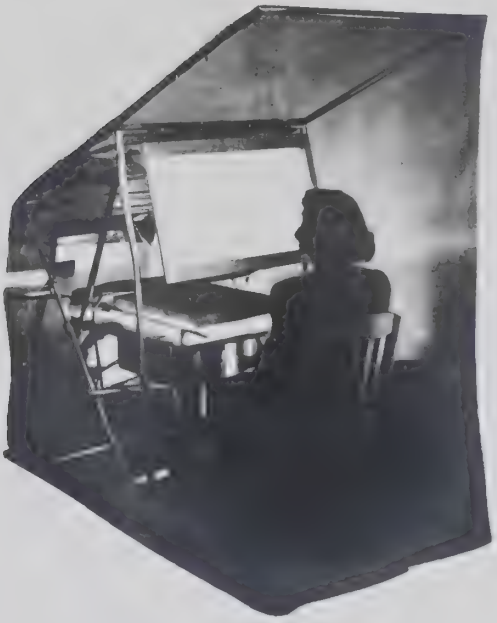


FIG. C-1 PHANTOM VIEW OF TYPE B PROJECTION MAGNIFIER, FRONT VIEW

FIG. C-2 PHANTOM VIEW OF TYPE B PROJECTION MAGNIFIER, SIDE VIEW

FIG. C-3 1 ST STEP IN OPENING FRAME

FIG. C-4 2 ND STEP IN OPENING FRAME

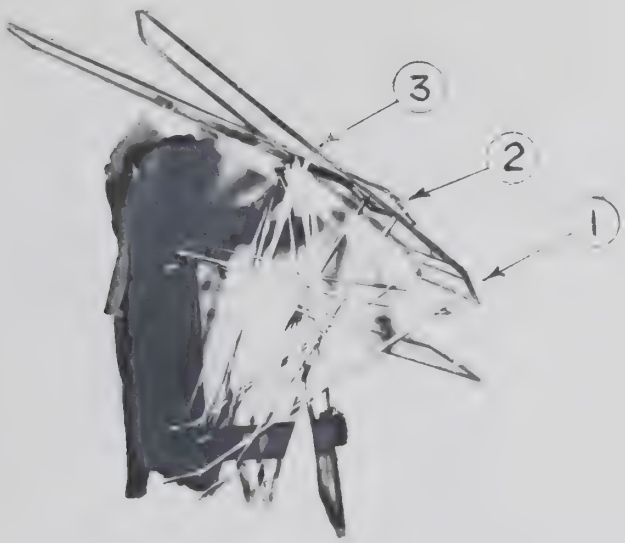


FIG. C-5 SLIDING TOP OF FRAME INTO PLACE

FIG. C-6 INTERMEDIATE STEP IN FRAME ASSEMBLY

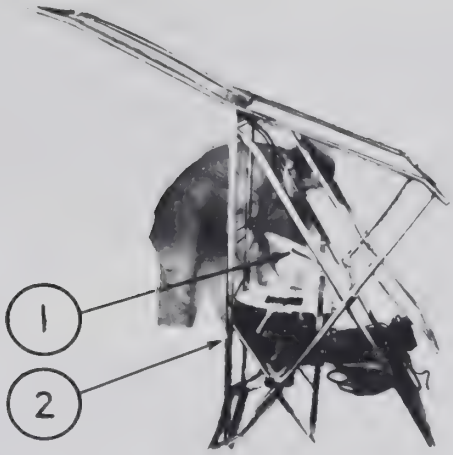


FIG. C-7 INSTALLATION OF LIGHT LENS BOX

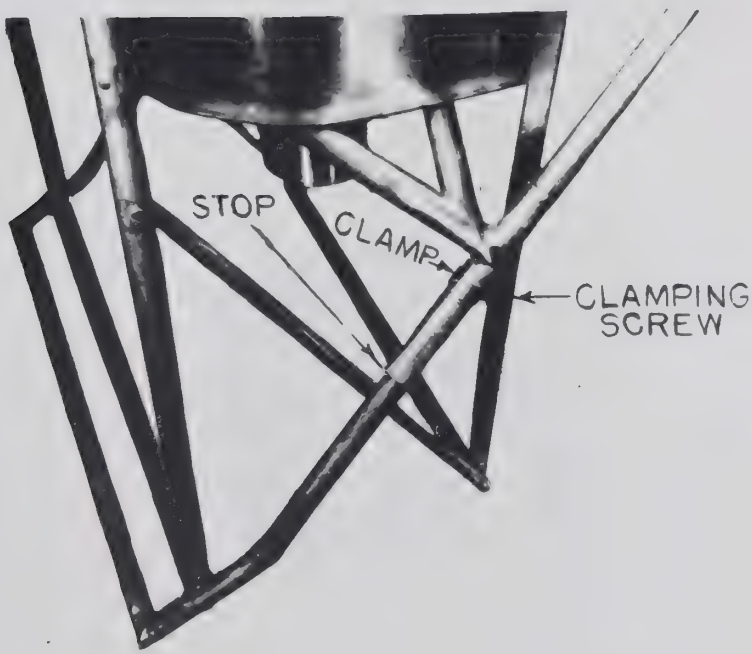


FIG. C-8 DETAIL OF LIGHT LENS BOX SUPPORT

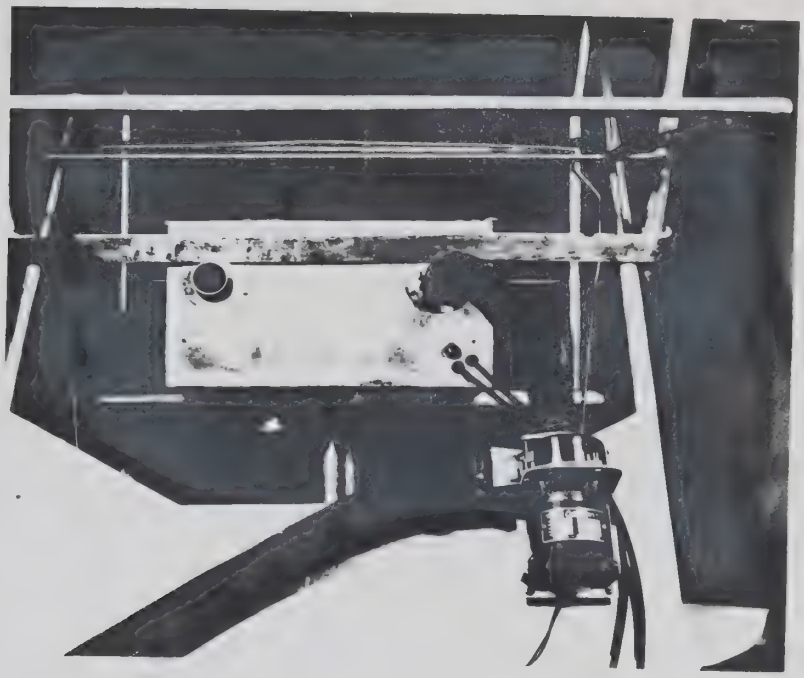


FIG. C-9 HOSE AND WIRE IN PLACE

FIG. C-10 INSTALLATION OF TABLE TOP

FIG C-11 INSTALLATION OF CLOTH SACK

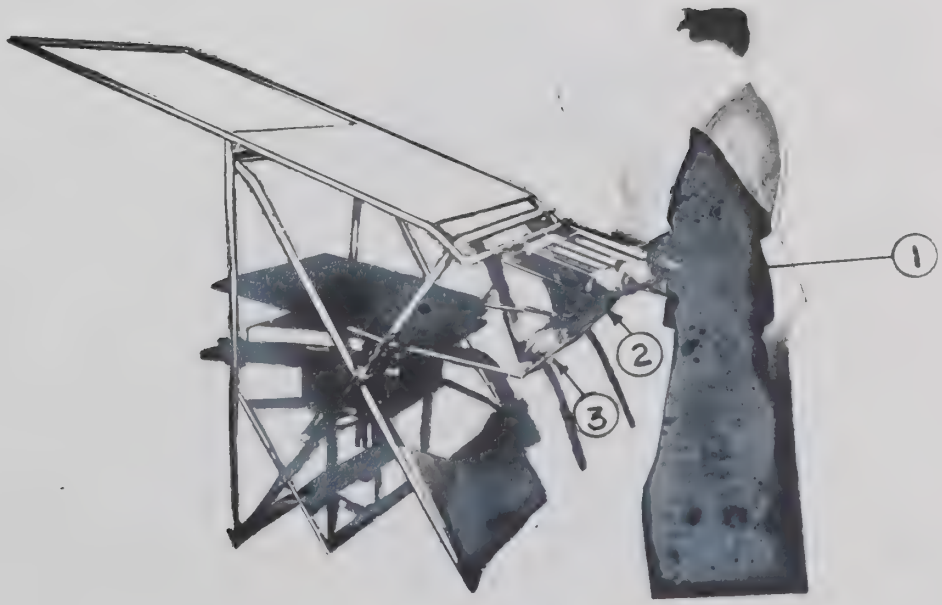


FIG. C-12 INSTALLATION OF REAR MOUNT

FIG C-13 INSTALLATION OF SCREEN FRAME

FIG C-14 PHANTOM VIEW, 25X MAGNIFICATION

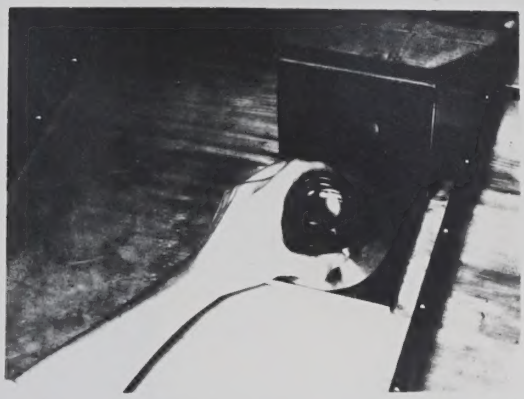


FIG. C-15 INSTALLATION OF 25X MAGNIFICATION LENS

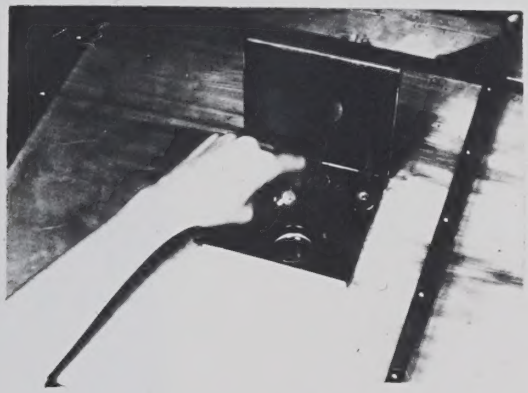


FIG. C-16 INSTALLATION OF LAMP

FIG. C-17 INSTALLATION OF 6X MAGNIFICATION LENS

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